Model Repetitive Loss Reduction Plan

US Army Corps of Engineers
New England Division

MODEL REPETITIVE LOSS REDUCTION PLAN

Conducted By:

U.S. Army Corps of Engineers
New England Division

For:
Federal Emergency Management Agency
Region I Office

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INTRODUCTION

STUDY PURPOSE AND SCOPE

The purpose of this study is to illustrate a model repetitive loss reduction plan that can be used by communities who wish to reduce flood losses resulting from repetitive loss properties.

The work was conducted by the U.S. Army Corps of Engineers, New England Division for the Region 1 office of the Federal Emergency Management Agency (FEMA) under its Community Assistance Program. The work was coordinated with the New England National Flood Insurance Program State coordinators and the officials of the community focussed on in the study.

The scope of work included:

- Choosing a repetitive loss community.
- Identifying the repetitive loss properties within the community.
- Defining the flooding problems that plague these properties.
- Identifying other possible structures that may experience repetitive flood losses.
- Selecting possible solutions that could be implemented to reduce repetitive losses.
- Developing a course of action to implement the selected plan.

NFIP AND REPETITIVE LOSSES

Since 1968 the National Flood Insurance Program (NFIP) has provided federally backed flood insurance so as to encourage communities to enact and enforce flood plain regulations. There are over 2.2 million policies in place. Since 1978, over 350,000 insurance losses have been paid out for a total of $2,500,000,000.

Of special concern to the NFIP is the high number of repetitive loss properties. A repetitive loss property is one which has sustained more than one flood damage event, with a payout of $1000 or more, since 1978. About 60,000 repetitive loss properties or 3% of all NFIP insured policies, account for 40% of the flood losses sustained since 1978. The NFIP's goal is to reduce the amount of these repetitive loss occurrences.

FEMA created the Community Rating System (CRS) in order to provide communities, participating in the NFIP, incentives to reduce flood losses. To participate in the CRS a community must make an effort to address its repetitive loss problem. According to the CRS guidelines this includes identifying the repetitive loss areas on a map and preparing a plan that describes the nature of the problem and solutions that would reduce the losses in those areas. Credit is awarded for reducing losses and allows the community to obtain lowered flood insurance premiums for its residents.

This study is an effort to develop a flood loss reduction plan. The community chosen for modeling the plan is Billerica, Massachusetts.

STUDY AREA

The town of Billerica is located in eastern Massachusetts approximately 20 miles northwest of Boston. Billerica is bordered to the north by the city of Lowell and the town of Tewksbury, to the east by the towns of Wilmington and Burlington, to the west by the towns of Chelmsford and Carlisle, and to the south by the town of Bedford. The town is approximately 26 square miles in size.

There are two major rivers in Billerica: the Concord and the Shawsheen. The Concord River is formed by the merging of the Assabet and Sudbury Rivers in Concord. It runs in a northerly direction for about 16 miles before joining the Merrimack River in Lowell. The Concord River is the town of Billerica's major water supply source. The Shawsheen River begins in the Bedford-Lexington area, parallels the Concord River in a northerly direction and flows into the Merrimack River in North Andover. There are no flood control structures on these rivers.

There has been development in the flood plain of these rivers, mostly in the form of vacation cottages, though some have more recently been converted to year-round residences.

As of the beginning of 1991, Billerica had a total of 132 flood insurance policies. Half of the policies are direct agreements with the Federal government, the other half come under the Write Your Own Program. There have been 117 claims filed since 1978 with a total payout value of $294,600. Of this, $196,000 or 67% of paid claims was due to repetitive loss properties. Though a participant in the NFIP, Billerica does not currently participate in the Community Rating System. This is not due to a lack of interest, but more to a lack of funding and personnel. At this time, their repetitive loss problems can only be addressed through existing zoning and conservation regulations.

PROBLEM IDENTIFICATION

The repetitive loss problem in Billerica has been rather high for an inland community. Coordination with FEMA and NFIP determined that there are 14 repetitive loss properties that have experienced 38 flood loss incidents from 1978 through 1991. These claims range from a few hundred dollars to a high of about $20,000 with an average claim of approximately $5,200. The most severely flooded property experienced a total of approximately $45,000 in flood damages spread over three events. A list of the general addresses and flood loss dates can be seen in Table 1.

The general location of these repetitive loss properties is shown on Figure 1. As can be seen on the map, the repetitive loss properties are spread out all over this community. Nine of the repetitive loss properties are located within the Concord River flood plain. Three others are located within the Shawsheen River flood plain. The Connolly Road property falls under the influence of Lubber Brook and the Acre Road property does not appear to be in the vicinity of any waterway or tributary.

TABLE 1
REPETITIVE LOSS PROPERTIES IN BILLERICA

	Property Address	Loss Date
1.	Faulkner Street	1/25/79 6/07/82 6/02/84
2.	Waterview Street	6/08/82 3/20/84
3.	Lombard Street	6/08/82 4/05/87
4.	Bridle Road	3/27/78 1/25/79 6/06/82
5.	Pelham Street	1/20/78 1/26/79
6.	Thoreau & Island Streets	6/08/82 6/05/84 4/06/87
7.	Colby Street	6/05/82 4/06/87
8.	Carter Avenue	1/25/79 3/05/83 4/06/87
9.	Riveredge Road	1/27/79 6/08/82 6/03/84 4/07/87
10.	Acre Road	6/18/79 1/04/82
11.	Pinegrove Avenue	1/04/82 5/31/84
12.	Summer Street	1/25/79 6/06/82 5/31/84 3/15/86 4/06/87
13.	Connolly Road	1/25/79 2/25/81
14.	Bellflower Road	2/17/82 6/04/82 4/01/87

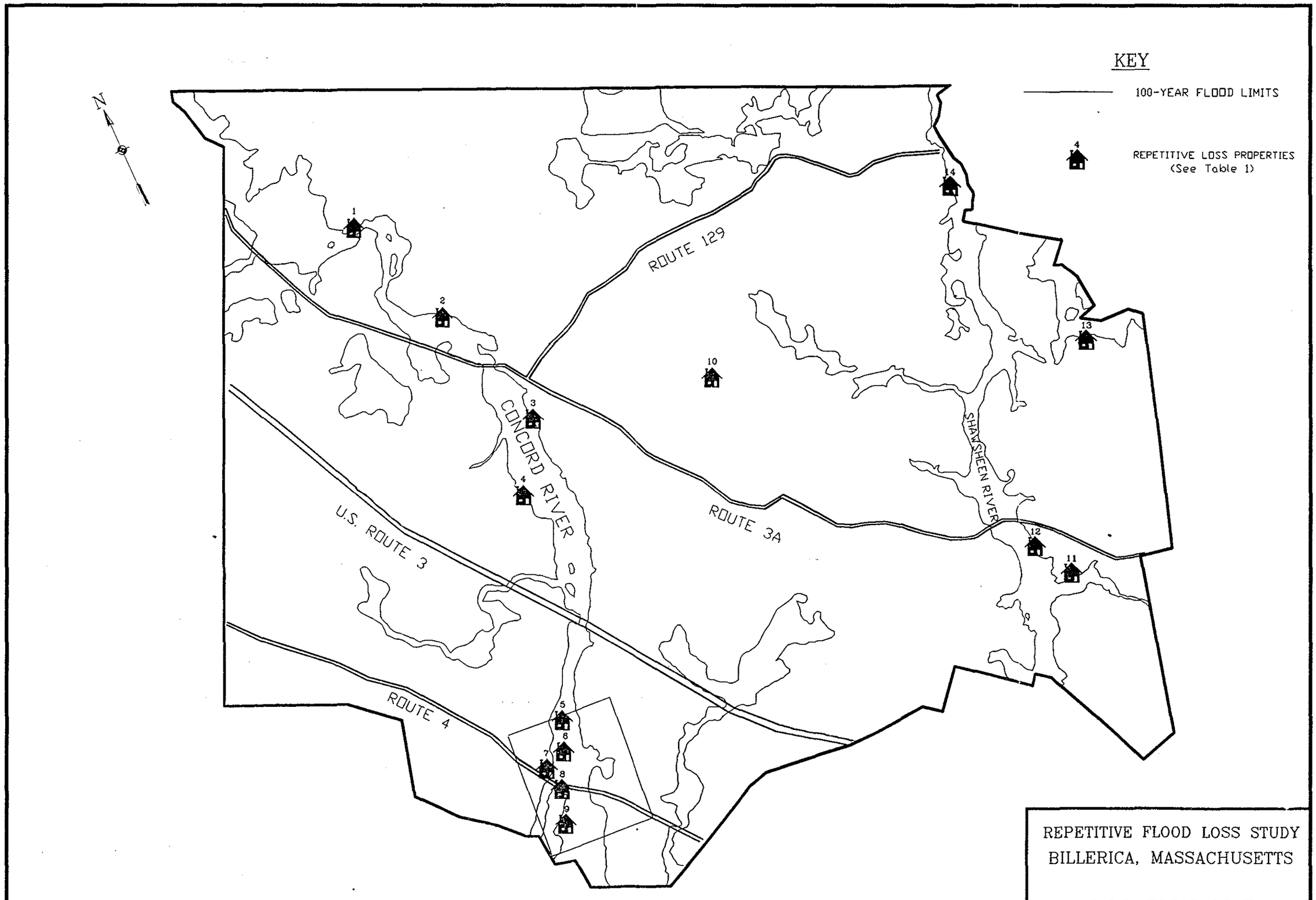
Based on a current list of insurance policy holders' obtained from the Town, seven of these properties no longer carry flood insurance. The Acre Road property experienced some subsurface basement flooding that was corrected a few years ago by re-sealing the foundation. The Lombard Street property has apparently done some recent work to raise the first floor of the structure above the damaging flood levels. There was no information available on the other properties to determine the reason for their discontinuance of flood insurance. However, a review of the NFIP claim data indicated that several of the properties no longer carrying insurance have received some of the largest flood damage claims. This would indicate that some action was taken by the property owners to mitigate the flood damage. The remaining properties no longer carrying insurance are those receiving the smallest claims. In these cases, either the property owners took some corrective actions or simply dropped the flood insurance due to the cost of the policy. This pattern of activity would indicate that those properties experiencing the highest and lowest damages will eventually take corrective actions or drop the coverage. The properties experiencing moderate damages, but not sufficient to justify corrective actions, will continue to experience repetitive flood losses. The remaining seven repetitive flood loss properties in Billerica have received 23 flood claims totalling $95,300 with an average claim of $4,150.

DESCRIPTION OF FLOODING PROBLEM

In order to determine the course of action for reducing a repetitive loss problem, an understanding of the cause and nature of the flooding must be reached. This study's scope does not allow a detailed analysis of each flooding event. However, using United States Geological Survey (USGS) data from the Lowell gage on the Concord River and the Route 129 gage on the Shawsheen River, it is possible to estimate the magnitude of each flooding event since 1978. The Flood Insurance Study for Billerica lists the 10-year, 50-year, and 100-year discharges as 2,885, 4,577, and 5,575 cfs on the Concord River at Route 3 and 1,020, 1,650, and 1,985 cfs on the Shawsheen River at Route 3A. The following discharges and frequencies for each flood event were calculated for the two rivers.

Concord River:

Flood Event	Discharge	Estimated Frequency
January 1978	2,487	< 10 year
March 1978	2,975	10 year
January 1979	4,786	60 year
June 1982	3,890	35 year
March 1983	3,177	15 year
March 1984	2,450	< 10 year
June 1984	3,585	25 year
April 1987	4,610	50 year



REPETITIVE FLOOD LOSS STUDY
BILLERICA, MASSACHUSETTS

LOCATION MAP

FIGURE 1

Shawsheen River:

Flood Event	Discharge	Estimated Frequency
January 1979	1,350	30 year
Jan/Feb 1982	598	< 10 year
June 1982	716	< 10 year
May 1984	383	< 10 year
March 1986	528	< 10 year
April 1987	940	10 year

Data for Lubber Brook was not readily available.

It is evident that the flooding events causing the repetitive damage claims are not major. In fact, only the January 1979 and April 1987 events were the floods of any real significance. None of the flooding over the past fourteen years came close to the magnitude of the estimated 100-year event. This is a common occurrence in most repetitive loss communities. Generally, the repetitive loss properties are the structures vulnerable to flooding from the events with a return frequency of 25 years or less. In the case of Billerica, the data indicates that the vast majority of repetitive loss claims have occurred from flood events with flood return frequencies of 35 years or less. Since the community has experienced several of these types of flooding events since the late 1970's and the community regulates development within the flood plain, the potential for additional repetitive loss properties is remote.

There is always the potential for a community to experience flooding from several statistically rare flood events over a short period of time. This would result in additional repetitive flood loss properties based on the FEMA definition. However, due to the slight probability associated with the flood problem, resolving the flood problem may not be economically cost effective. If a community wishes to maximize its resources, it should focus its effort on resolving the flood problems associated with the more frequent events. These can be identified by evaluating the hydrologic data and the computed flood profiles in the communities' Flood Insurance Studies and comparing the frequent flood event elevations with the first floor elevations of the properties in the flood plain. Topographic mapping is very useful in conducting this analysis.

Due to the limited nature of this study, in both time and funding, the following discussion on reducing repetitive losses will focus on the lower portion of the Concord River. The area of focus is outlined by the rectangle on Figure 1. This area was enlarged and can be seen in Figures 2A and 2B. The repetitive loss properties have been highlighted in red, while those properties identified as being in the flood plain with the potential to experience future flood losses are highlighted in yellow. The area shown represents the heaviest concentration of repetitive loss properties in the town of Billerica.

REVIEW OF ACTIVITIES TO REDUCE REPETITIVE LOSSES

In general, there are two different ways to approach the reduction of flood damages: structural and nonstructural. Structural measures include: dams with reservoirs, channels, dikes, walls, diversion channels, and bridge modifications. The intent of these measures is to reduce the frequency and/or the stage of flood flows in the river. Though mentioned here, these methods will not be explored further as they tend to be expensive and are more suitable in protecting more concentrated development. The repetitive loss properties experienced in Billerica are very spread out and do not lend themselves to these types of improvements. The amount of potential losses to other properties vulnerable to flooding, as shown in Figures 2A and 2B, is not significant either. The isolated characteristics, uniformity of residential structures, and lack of available funds in Billerica make nonstructural measures more attractive in eliminating these repetitive losses.

Nonstructural solutions include: flood proofing, permanent relocation of structures, flood warning systems, and the purchase or regulation of flood plains. Flood proofing measures include: elevating buildings, relocating or protecting damageable property within the building, sealing walls, protecting utilities, temporary or permanent closures, and installing pumps and valves. A copy of a report entitled "Flood proofing: A Guide For Property Owners", completed by the New England Division of the Corps of Engineers in 1981, is presented in Appendix B. Although the cost information presented in the report may be dated, the report presents an excellent discussion of the types of nonstructural activities available to property owners.

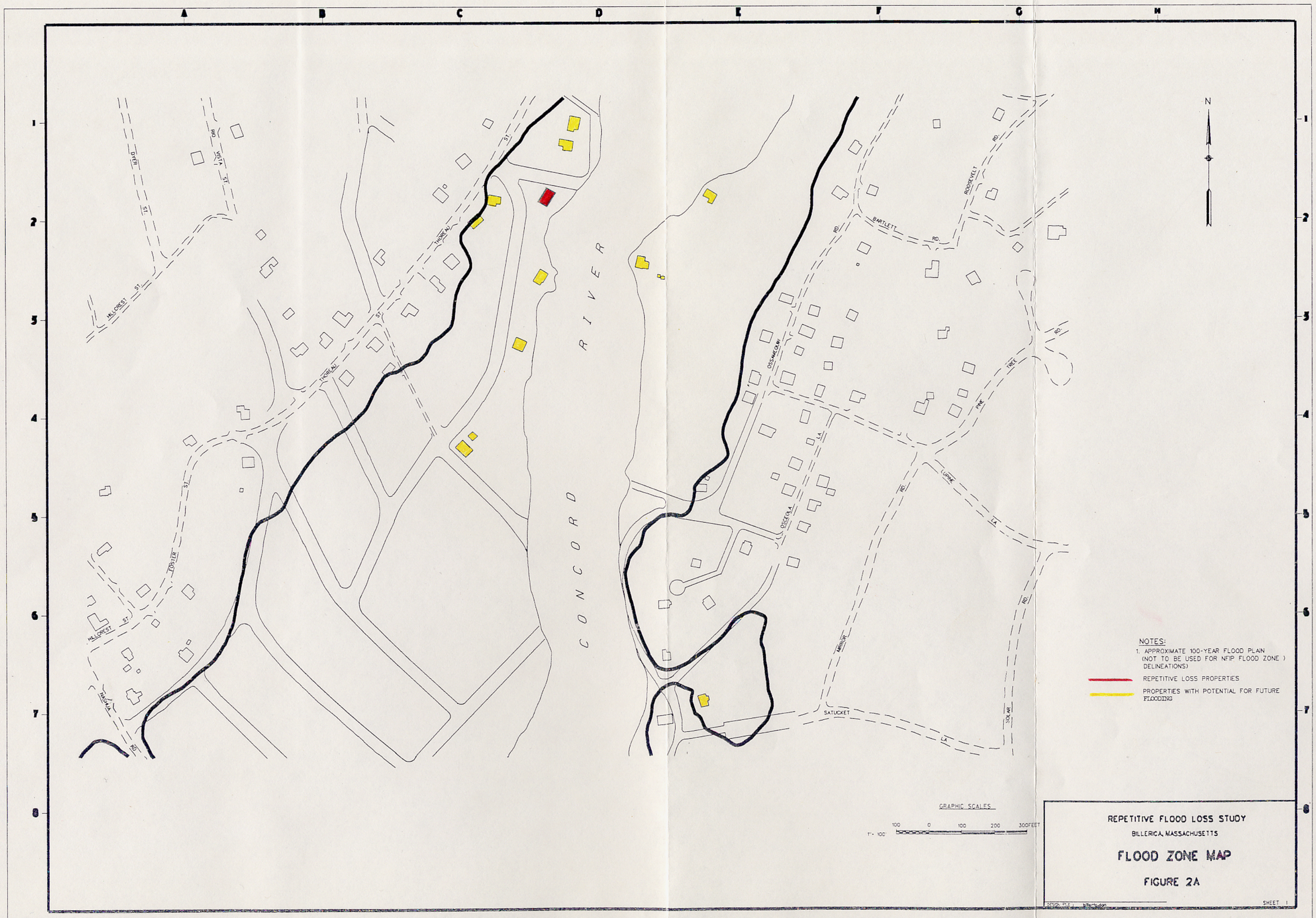
All of these nonstructural measures available to address repetitive flood loss problems fall into the categories of actions identified in the CRS. By participating in any of the CRS activities, a community can reduce the cost of flood insurance to its property owners. The actual calculation of credits associated with the resolution of the repetitive flood loss problem in Billerica will not be conducted as part of this study. However, the Town can use work sheets provided in the CRS manual to determine the value of those actions they choose to take.

The most suitable nonstructural activities available to the Town to address the repetitive flood loss problem are as follows:

1. Public Assistance
2. Flood Warning and Preparedness Systems
3. Drainage System Maintenance
4. Retrofitting
5. Acquisition and Relocation

1. Public Assistance:

One of the easiest and most direct ways of reducing flood losses is to inform people of their problem and suggest ways they can correct it. Most, if not all, of the repetitive loss owners in Billerica are aware of their problem: they live in the river's flood plain. However, research shows that


A
B
C
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7
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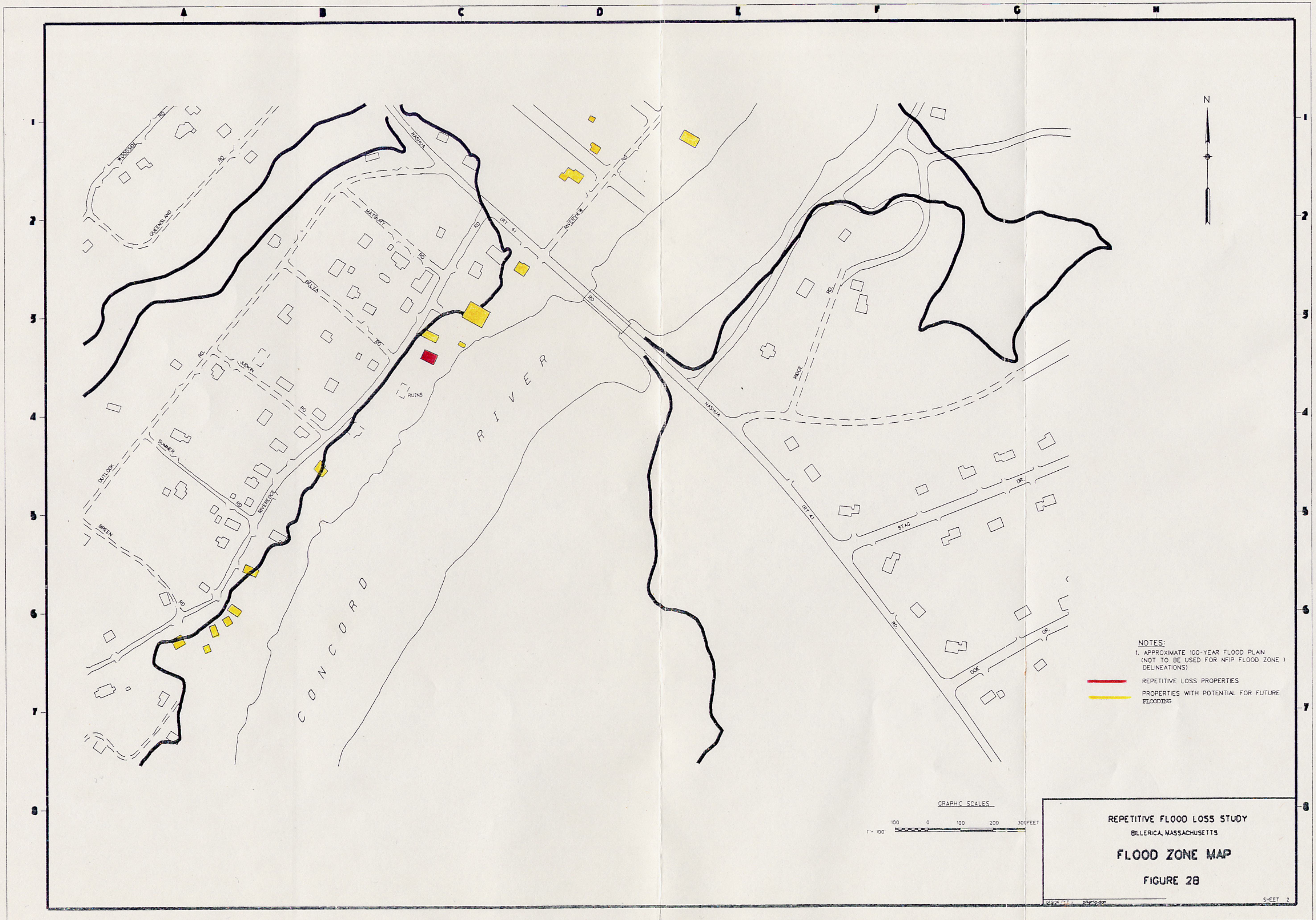
DYER ST.
RIO VISTA ST.
HILLCREST ST.
THOREAU ST.
THOREAU ST.
FOSTER ST.
HILLCREST ST.
TUSKEGIA RD.
CONCORD RIVER
BARTLETT RD.
ROOSEVELT RD.
OSSIAWEOGAN RD.
OSSIAWEOGAN LA.
OSSIAWEOGAN RD.
LUPINE RD.
LUPINE LA.
MANOR RD.
SATUCKET LA.
SOLAR RD.
N
NOTES:
1. APPROXIMATE 100-YEAR FLOOD PLAIN (NOT TO BE USED FOR NFIP FLOOD ZONE) DELINEATIONS)
REPETITIVE LOSS PROPERTIES
PROPERTIES WITH POTENTIAL FOR FUTURE FLOODING
GRAPHIC SCALES
100 0 100 200 300FEET
1" = 100'
REPETITIVE FLOOD LOSS STUDY
BILLERICA, MASSACHUSETTS
FLOOD ZONE MAP
FIGURE 2A
SHEET 1


NASHUA RD (RT 4)
RIVERVIEW RD
MAYBURY RD
BELVIA RD
JUDKINS RD
SUMNER RD
RIVERSIDE RD
OUTLOOK RD
QUEENSLAND RD
WOODSIDE RD
BREEN RD
RUINS
CONCORD RIVER
RIDGE RD
STAG DR
DOE DR
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REPETITIVE FLOOD LOSS STUDY
BILLERICA, MASSACHUSETTS
FLOOD ZONE MAP
FIGURE 28
SHEET 2

by "reminding" people of the problem and at the same time informing them of ways to protect their property against flood damage, progress to reduce flood loss may be made.

This can be done by the Town in two simple steps. First, by sending a notice to individual residents of flood-prone areas. Secondly, by following up the notice with an information packet on flood proofing or an advertised information show. Representatives from NFIP, FEMA, and the Corps of Engineers could be invited to advise homeowners.

The Town can also provide assistance by additional flood hazard information to interested residents. This could involve the Town publicly announcing the opening of an office that would provide technical advice to interested property owners. The types of information provided could include: mapping of flood prone areas, first floor elevations of properties, flood elevations, velocities, durations, and a history of damages, injuries, or deaths resulting from different events (see Appendix A for example of technical literature).

It should be noted that there are programs, at the state and Federal level, to solve flooding problems. Any community that is faced with significant flooding problems should contact the Army Corps of Engineers, the Soil Conservation Service, and/or the state's flood management agencies.

2. Flood Warning and Preparedness Systems:

A flood warning and preparedness system can be a cost effective means of dealing with flooding on a regional basis or for a concentrated grouping of structures. This is accomplished by providing advanced warning of the potential for flooding at a predetermined flood plain damage center. The advanced warning is used in conjunction with a flood preparedness plan to evacuate vulnerable areas and allow for time to implement flood damage reduction measures such as removing or elevating building contents. The costs of a flood warning system and the preparation of a preparedness plan vary greatly with the degree of system implemented. The hardware associated with a system is relatively inexpensive, costing approximately $25,000 to $30,000 for a small drainage area. The preparation of a detailed response plan is typically the responsibility of the community and should be considered a significant undertaking.

In terms of eliminating the repetitive losses in Billerica, a flood warning system and preparedness plan is probably not the most cost effective solution because the properties are dispersed throughout the community. Flood warning and response systems are more appropriate for concentrated areas of development.

3. Drainage System Maintenance

Sometimes a localized flooding problem can be the result of a drainage problem. Town maintained channels and detention basins lose their carrying capacity due to debris, sedimentation, or vegetation. Once a portion of a drainage system loses its carrying capacity, runoff is more likely to overflow onto nearby property.

To avoid this a community must inspect its drainage system on a regular basis and remove debris. A community's drainage system is typically seen as rivers, streams, canals, ditches, channels, stream enclosures, ditches, culverts, bridge openings, and town operated retention basins.

In the case of Billerica, none of the repetitive flood losses were caused as a result of a drainage problem for which the town was responsible. One property apparently had some shallow basement flooding due to underground streamflow. That was corrected by the owners using sealants to floodproof the foundation.

4. Retrofitting

Retrofitting repetitive loss structures involves the modification of the structure to protect either the building and/or the contents against damaging flood waters. There are three basic methods of achieving this:

1. Raising the structure.

2. Constructing barriers to keep flood water out of the building.

3. Relocating contents above flood levels.

a. Raising Structures:

The first method, raising the structure, involves jacking the building up and setting it on an extended foundation. The goal is to get the first floor one (1) foot above the base flood elevation (per Flood Insurance regulations). The technology exists to raise almost all structures, however, the more difficult the raise, the more costly the job. Residential structures have been successfully raised up to nine feet. Within the normal range of average annual flood damages, raising in place is most applicable to structures which can be raised with low cost conventional means. Generally this means structures, 1) that are accessible below the first floor for placement of jacks and beams, 2) light enough to be jacked with conventional house moving equipment, and 3) small enough so it doesn't need to be partitioned.

Wood framed residential and light commercial structures with their first floors (with typical 18" crawl space) above ground are most suitable for raising. Wood framed structures with basements can also be raised but it is necessary to elevate damageable contents and allow flooding to equalize hydrostatic pressures in the basement or fill the basement completely. Slab on grade structures can be raised but is more costly due to special excavation and lifting techniques.

Raising a building typically involves the following construction steps:

- Disconnect all plumbing, wiring, and utilities which cannot be raised with the structure.
- Place steel beams and hydraulic jacks beneath the structure and raise to the desired elevation.
- Extend existing or construct a new foundation.
- Lower the structure onto the new foundation.
- Adjust or relocate walks, steps, ramps, and utilities and re-grade as desired.
- Re-connect all plumbing, wiring, and utilities.
- Insulate exposed floors to reduce heat loss and to protect plumbing, wires, and utilities.

This method of flood proofing is possible for most of the repetitive loss properties in Billerica. The properties identified in Figures 2A and 2B need to be raised between two and five feet in order to be above the NFIP 100-year flood elevation (approximately 119 feet NGVD). This can certainly be done and has been done in other areas of Billerica. Figure 3 shows two properties that have elevated structures. In order to be effective though, damageable property and utilities must be moved out of the lower level.

Costs for doing this work need to be estimated on a case by case basis. Recent estimates for Corps studies show the cost of raising a wood framed structure to be about $30,000 to $40,000, depending on whether the structure had a full basement or not. By using the above scope of work and flood elevation developed for the structure, individual owners can obtain estimates for the cost of doing this work.

b. Constructing barriers:

The second method, constructing barriers to keep out flood waters, can also be an effective method of mitigating flood damages to repetitive loss properties. There are two variations of this method: berms and flood walls; and temporary closures for openings.

Berms and flood walls completely surround a structure and are usually constructed to a height in excess of the base flood elevation. Berms are typically constructed of earthen materials that are impervious to leaching. The flood walls are usually constructed of reinforced concrete and are anchored to withstand hydrostatic loading. Both types of structures are suitable for flood proofing against waters six feet deep or less. An internal sump and pump system to take care of interior drainage and protection against sewer back-up is also part of this work.

The average homeowner in Billerica cannot afford, in land and dollars, this type of work. These methods are certainly functional for the type of flood problems being experienced in Billerica. However, the size of the lots do not lend themselves to this solution. In addition, Town approval would be contingent on mitigating for the loss of flood storage. This amount of mitigation is beyond the means of the property owners who are being discussed here.

Temporary closure of building openings, or "dry flood proofing", is another method of keeping floodwaters out of buildings. Though not as expensive as those methods previously discussed, closures are very limited to what structures they can be used in. Structures whose exterior is generally impermeable to water can be made to be "water-tight" by installing closures over openings like doorways and windows. The closures are constructed to make a "dry" seal and can usually be set in place with a minimum amount of effort and advanced warning.

Structures with exterior walls constructed of brick, concrete, or concrete block are relatively impermeable to water and can be considered for closures. However, the condition of the walls, the location, size, and spacing of openings must be studied carefully before closures can be recommended. Structures with sidings made of wood, sheet metal, aluminum, or masonite are very difficult to keep water out of and are not suitable candidates for closures.

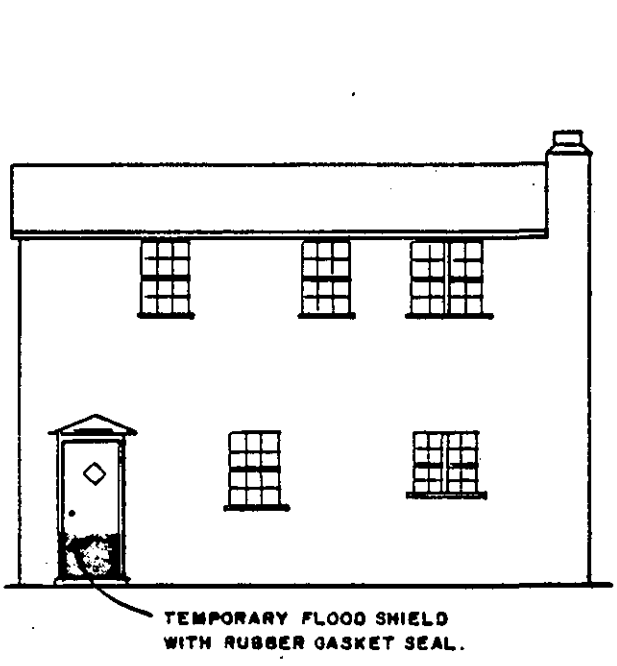
The problem is that regardless of whether the structure is residential, commercial, or industrial, most have not been designed to withstand the hydrostatic pressure on exterior walls. The principal reason more structures do not collapse during flooding is that water enters the structure and equalizes pressure inside and outside. Once closures are used, this pressure becomes a major consideration. The Corps of Engineers Structures Laboratory has determined that 3 feet of water above grade is the allowable depth for masonry commercial or industrial structures. Common wood framed houses are too susceptible to failure, either through wall collapse, floatation of the structure, or buckling of slab on grade floors, to recommend the use of closures.

Closures or dry flood proofing is not a very useful method of flood proofing for the repetitive loss structures in Billerica. Almost all the buildings in question are simple wood framed structures. Only one property, a commercial concrete and brick building, is potentially capable of withstanding the forces associated with closures. An example of different uses of closures can be seen in Figure 4. Temporary closures for this building would require some prior frame assembly. Based on recent Corps estimates the complete installation costs for a first floor window would run about $1,500 to $2,000 per unit. Costs for a commercial entrance were estimated at around $4,000 per unit. The Corps of Engineers has extensive literature detailing the various methods of closures that are available for public use. A list is included as part of Appendix A.

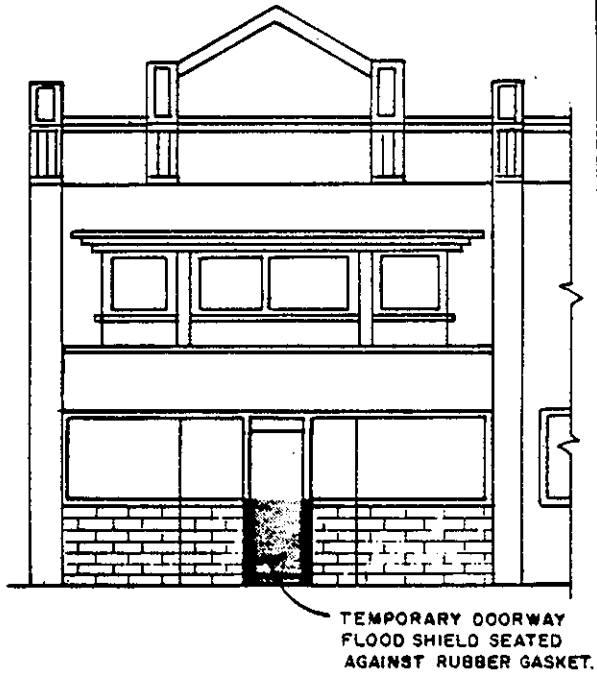
REPETITIVE FLOOD LOSS STUDY
BILLERICA, MASSACHUSETTS

ELEVATED STRUCTURES

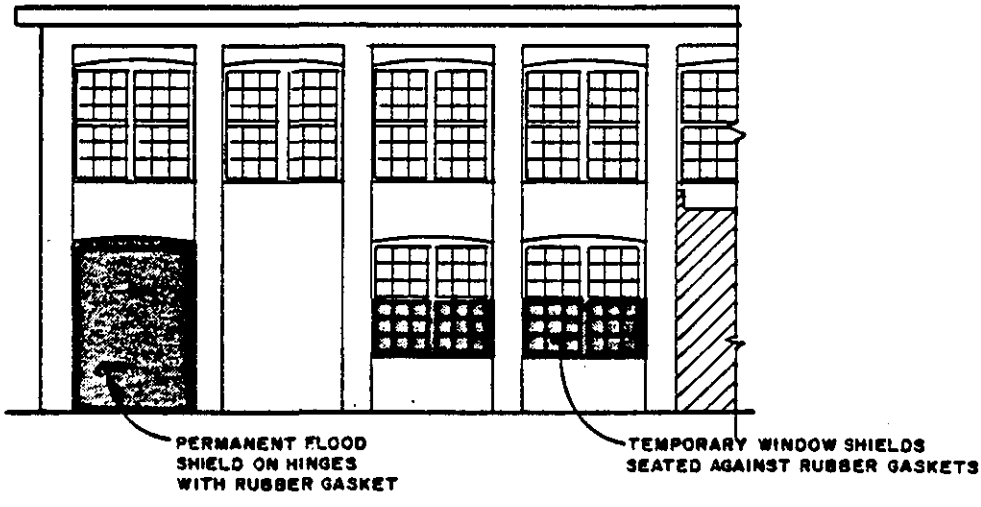
FIGURE 3



TWO STORY BRICK
RESIDENTIAL STRUCTURE



ROW STRUCTURE



COMMERCIAL / INDUSTRIAL STRUCTURE

Figure 4 Temporary and Permanent Closures

c. Relocating Contents:

The third method of retrofitting involves relocating contents and modifying the structure to allow water to enter. This method is often referred to as "wet flood proofing". Floodwaters are allowed to enter the structure but utilities and contents are protected or relocated above the base flood level. This method is generally used in situations where there is an area available above flood levels to which damageable items can be located to or temporarily stored, usually the first or second floor. This is often the case with buildings having basements. Of course there must be sufficient warning of an impending flood in order to have time to move contents. Furnaces, fuel tanks, hot water heaters, electric circuit panels, washers, and dryers are more difficult to relocate. The space is not always available. Even if space were available, alterations of duct work, plumbing, and wiring are often necessary. Contents can be moved to temporary storage elsewhere, such as an attic or shed. Sometimes if the flooding is shallow, equipment or merchandise can be raised off the floor with a pedestal or table.

The degree to which property can be rearranged and protected is certainly site specific. It is very dependent on the flood's frequency and depth, the type of property, moveability, and the availability of nearby, less flood prone areas. The more that can be relocated above the base flood elevations, the less chance damage will result. Regardless of the effort, though especially during an inundation event, it is nearly impossible to avert all building and contents losses.

Costs for this work are varied. Raising an item in place can certainly be done cheaply; the cost increases as the detail of work increases. A few concrete blocks to raise a washer in place would cost a few dollars as opposed to a concrete pedestal to support factory machinery. In the same way providing storage on an upper floor would be very inexpensive compared to constructing a new utility room on the side of the building which could cost several thousand dollars.

With regard to Billerica, there may be opportunities to reduce flood damages to the repetitive loss properties by relocating contents to higher levels within the structures. It would be expected that property owners subjected to frequent flooding would have performed the simple tasks of relocating contents to safe locations. However, there may be opportunities to raise heating systems, appliances and other utilities to higher elevations. Each individual property would need to be assessed as to the type of "wet-flood proofing" needed and the associated cost.

5. Acquisition and Relocation

This activity is the surest way of eliminating repetitive loss problems. Acquisition involves purchasing the property in question and removing or demolishing the existing structure. Relocation involves having the owner move the building to ground above the base flood elevation at the site or removing it entirely outside the flood zone.

This method of repetitive loss reduction is effective only if the funds are available and in Billerica's case, they are not. When basic funding problems exist for schools and town services, acquisition of flood prone properties is generally considered a low priority. However, it does not mean that other avenues of funding cannot be explored.

As part of this reduction plan two alternate sources of funding will be described briefly. The two, the Section 1362 - Acquisition Program and the Hazard Mitigation Grant Program, are both FEMA based programs. They allow a community or state to obtain funding to remove or relocate structures in flood prone areas.

Through Section 1362 of the NFIP, FEMA has the authority to purchase flood damaged property and give the owners a chance to relocate. Criteria used to determine if FEMA will buy the structures include:

a. The owner must have a flood insurance policy at the time of the damage.

and at least one of these others:

b. The structure must have been damaged by at least three previous floods in the last five years, with an average damage of 25% or more of the structure's value.

c. A single flood has damaged the structure 50% or more of its value or is beyond repair of its pre-flood condition.

d. Any flood event has damaged the structure to the point of being irreparable, either due to local regulations or significantly increased building costs.

The process involves determining a fair market price for the property and once a negotiated price is reached, an agreement between FEMA and the owner is made. The land or land and structure are bought by FEMA and turned over to the community. The land is then cleared and used for recreation or conservation purposes. The program offers owners a chance to sell their property that they might not have otherwise and save the local government costs to provide emergency services.

In the town of Billerica, none of the repetitive loss properties identified appear to fit the criteria to participate in the 1362 Program. None of the properties meet the frequency requirement and only properties on Riveredge Road and Carter Avenue, in 1979, have sustained damages even remotely close to 50% of the structure's value. The Town may want to check into this further. Regardless, they should be aware the program exists and should keep up to date flood damage records in order to take advantage of a purchasable situation when it arises.

Another method available is the Hazard Mitigation Grant Program. The purpose of this FEMA sponsored program is to provide 50/50 matching funds to states, and through them, to local communities to enable them to provide long term hazard mitigation measures to be used following a Federal disaster

declaration in a particular state. FEMA will fund up to 50% of the cost of acquisition and relocation of structures prone to flooding. The state or local match can be met with in-kind services. Applicants for the grant must apply through the state. Applicants should contact the State Hazard Mitigation Officer for details of the program. All proposals for the grant must be submitted within 90 days of a declared disaster.

Of course, in order for the town of Billerica to utilize this program there first needs to be a declared Federal disaster. Again, however, the Town may want to just be aware of the program now or even go so far as to contact the state's Hazard Mitigation Officer to begin formulating a proposal for property acquisition.

EVALUATION OF SOLUTIONS

The initial screening of nonstructural alternatives identified several measures which could be used to address the repetitive flood loss problem in Billerica. The two measures which this report will investigate further are Acquisition and Relocation, and Raising of Structures. Raising the contents and utilities in the repetitive flood loss properties could also result in reduced flood damages. However, the analysis is site specific to the contents and layout of the structure and, therefore beyond the scope of this study. The method used to evaluate the cost effectiveness of this measure is identical to the analysis which will be presented for the two selected alternatives. Increasing public awareness to the threat of flooding is also an action which the town of Billerica should use to publicize flood damage reduction techniques and encourage actions by the individual homeowners.

The decision to implement a flood damage reduction plan is made by comparing the cost of the alternatives versus the damages prevented over the life span of the project. This analysis can be a simple comparison of the project cost versus the damages that have been experienced by the homeowner. For example, one of the remaining repetitive loss properties has two claims since 1978 totalling approximately $5,500. By simply comparing this value to the $30,000 to $40,000 required to raise the structure indicates that this is probably not an economically sound investment. Alternatively, one of the Repetitive Loss Properties has experienced approximately $24,000 in damages spread over 4 claims. A comparison of these damage amounts indicates that raising the structure may be economically feasible and should be pursued further.

The Corps of Engineers performs a more comprehensive analysis to assess the economic feasibility of constructing flood damage reduction projects. This method involves the comparison of the projects costs versus the statistically calculated damages prevented over the life of the project. The results of the analysis provides a benefit to cost ratio for the project. The following is a demonstration of this technique for a sample Repetitive Loss property in Billerica. The numbers used will be based on a one family wood frame structure with a basement. The benefits used in the analysis are based on prior Corps investigations and are not specific for any one property in Billerica.

The one family dwelling is assumed to be located in the flood plain with a first floor elevation 2 feet below the 100-year flood level. In the lower Concord River reach this would equate to a first floor elevation of 117.0 NGVD. As part of the study, stage-frequency and stage damage curves were developed. The curves can be found in the supporting Appendix A. The stage-frequency curves were developed for two reaches of the Concord River. The stage damage curve was developed from prior Corps of Engineers investigations and presents an "average" of damages found to be associated with this type of building. In a more comprehensive study, damages for each building would be investigated. For purposes of this report, the use of a typical curve was determined to be sufficient. Using data from the two curves, a third relationship, damage-frequency, was developed. This curve can also be found in the Appendix A. The area under this curve is the estimated average annual damages experienced by the structure.

Acquisition costs for property owners in these flood prone areas are certainly site specific. For purposes of this comparison, assessed property values (structure and land) for these flood prone sites were obtained from discussions with the Town Assessor's Office. A typical property value was determined to be around $100,000. If you include monies for other miscellaneous expenses, the total cost of acquisition is estimated to be around $110,000 per property. Based on a figure of $110,000 and an amortization rate of 8 1/2% (50 year project life) the annual cost is $9,500.

Acquisition and relocation could also be accomplished by buying up only the land and moving the structure to a new lot. The lot value is estimated to be around 60% of the property value or $60,000. If one adds in expenses for moving the structure ($10,000), the total cost of the effort is about $70,000. The annual cost in this case would be $6,000. This is less expensive than completely buying out the owner.

As mentioned previously, raising of the subject structure is certainly feasible. The cost of raising a wood framed structure, with a basement, is about $40,000. This is equal to an annual cost of $3,500. The first floor of the structure would be raised one foot above the 100-year flood elevation of 119.0 feet NGVD. The difference of a few feet in raising this type of structure is not significant since the majority of the costs are associated with the mobilization efforts.

A summary of an example benefit/cost analysis for these methods can be found in Table 2.

TABLE 2
Summary of Economic Analysis

Method	Annual Benefit	Annual Cost	Benefit/ Cost Ratio
Acquisition	$ 3,500	$ 9,500	0.4
Acquisition and Relocation	$ 3,500	$ 6,000	0.6
Raising the Structure	$ 3,500	$ 3,500	1.0

The benefits shown include a flood damage reduction benefit and a $350 flood insurance premium savings to the property owner. The Corps, under its evaluative regulations, would only be allowed to take an $80 benefit which accounts for the NFIP operational cost per policy. For purposes of this analysis the entire premium savings was used. There would also be benefits to the town in terms of savings of emergency services, the value of the acquired land for recreational and conservation use, and the reduction of insurance rates for the entire town, through the CRS, that could be gained if repetitive loss reduction measures were implemented. These benefits were not quantified during this limited study. However, these are items that town officials should consider in their own evaluation.

RECOMMENDED REPETITIVE FLOOD LOSS REDUCTION PLAN

During the course of this study we were able to: identify all the repetitive loss properties in Billerica, define the flooding problem, identify that additional repetitive loss structures are not likely, and identify possible solutions to reduce these repetitive flood losses.

As was just demonstrated, there are some relatively inexpensive ways to reduce flood losses. These methods could potentially be useful for Billerica and its few and dispersed repetitive loss properties. Larger structural solutions would not be cost effective. A hypothetical economic analysis was conducted to demonstrate the method of evaluating the cost effectiveness of the more applicable nonstructural solutions.

Based on this study the following recommendations to reduce repetitive flood losses in the town of Billerica are made.

1. The town of Billerica should actively participate in the Community Rating System. Participation would provide additional incentive to reduce these flood losses and, in turn, reduce flood insurance premiums.

2. The town of Billerica should conduct an outreach program where they "remind" the owners of these repetitive loss properties of their problem and that there are methods of reducing the damage.

3. The town of Billerica should make available to these individual owners technical information regarding flood proofing such as the report included in Appendix B. Methods such as flood proofing barriers, relocating contents, or raising the structure are proven ways of reducing flood losses. Other technical reports that could be useful to the community are listed below:

   - Elevated Residential Structures, Federal Emergency Management Agency. Washington, D.C., U.S. Government Printing Office, March, 1984.

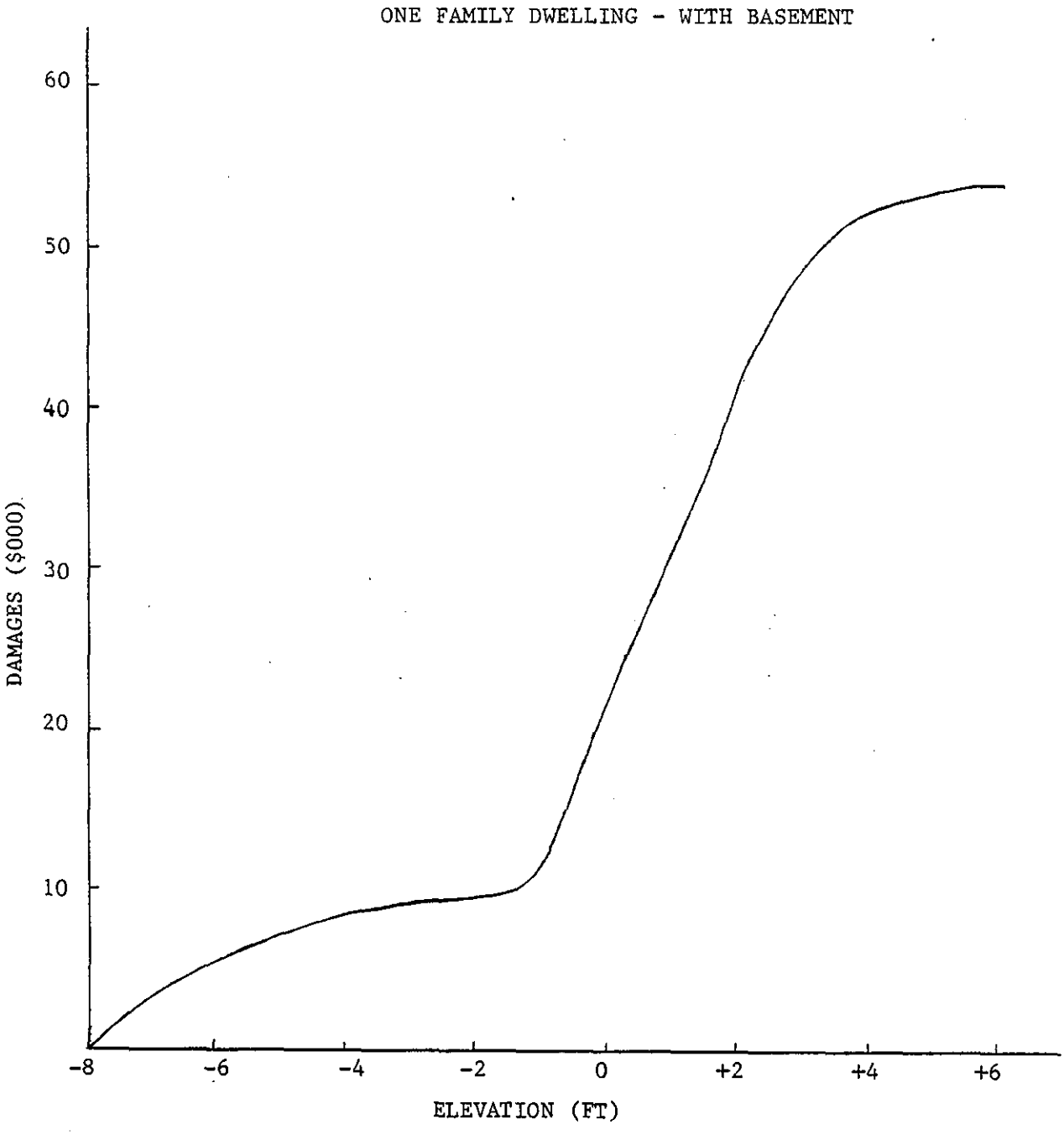
   - Design Manual For Retrofitting Flood-Prone Residential Structures, Federal Emergency Management Agency, Washington, D.C., U.S. Government Printing Office, September 1986.

   - Flood Proofing Non-Residential Structures, Federal Emergency Management Agency, Washington, D.C., U.S. Government Printing Office, May 1986.

   For additional references, see the report Appendix A.

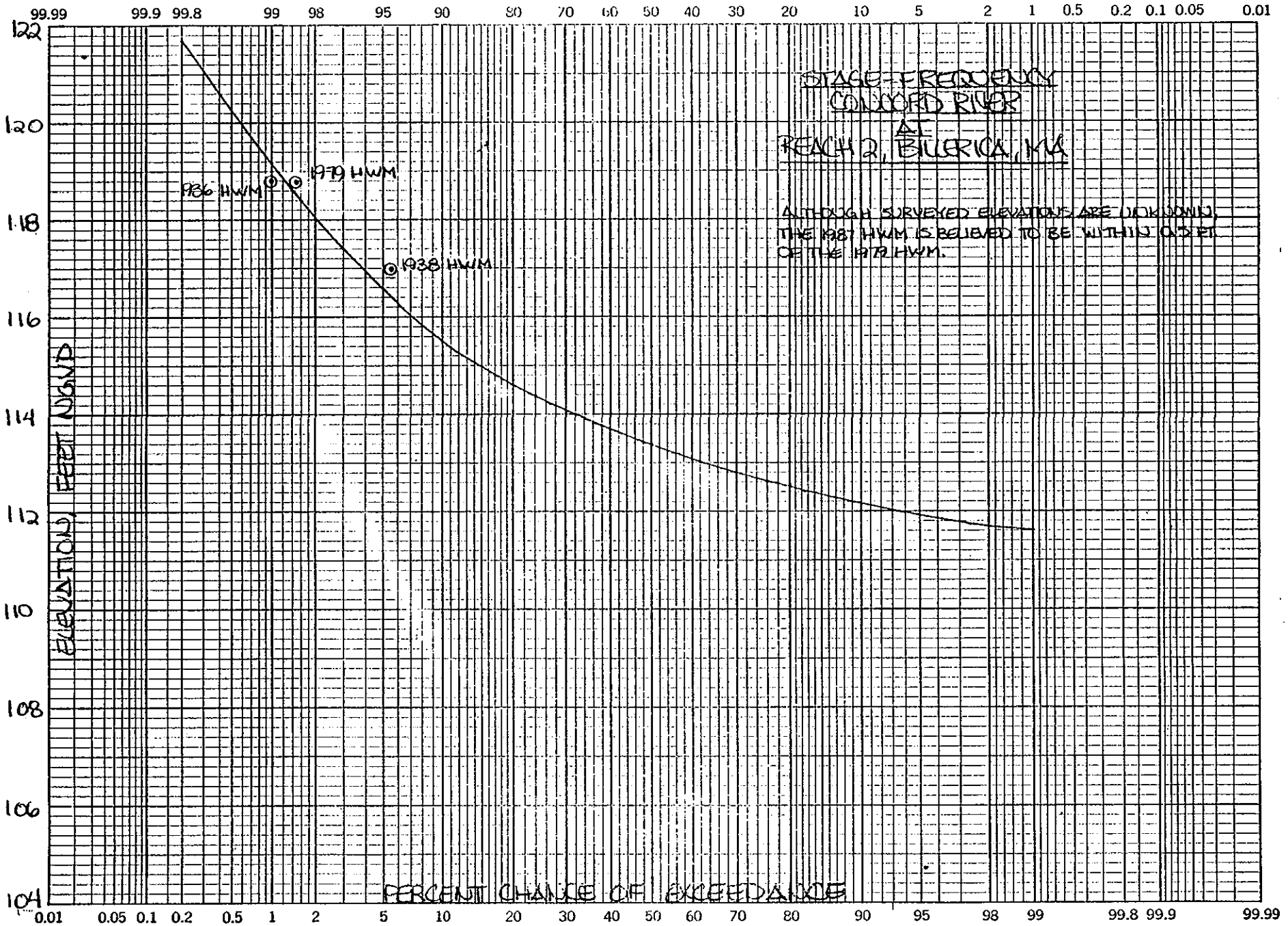
4. The town of Billerica should monitor the flood loss properties and acquire those properties that are especially troublesome if the opportunity is available through one of the federally funded programs. This is the surest way of eliminating future losses.

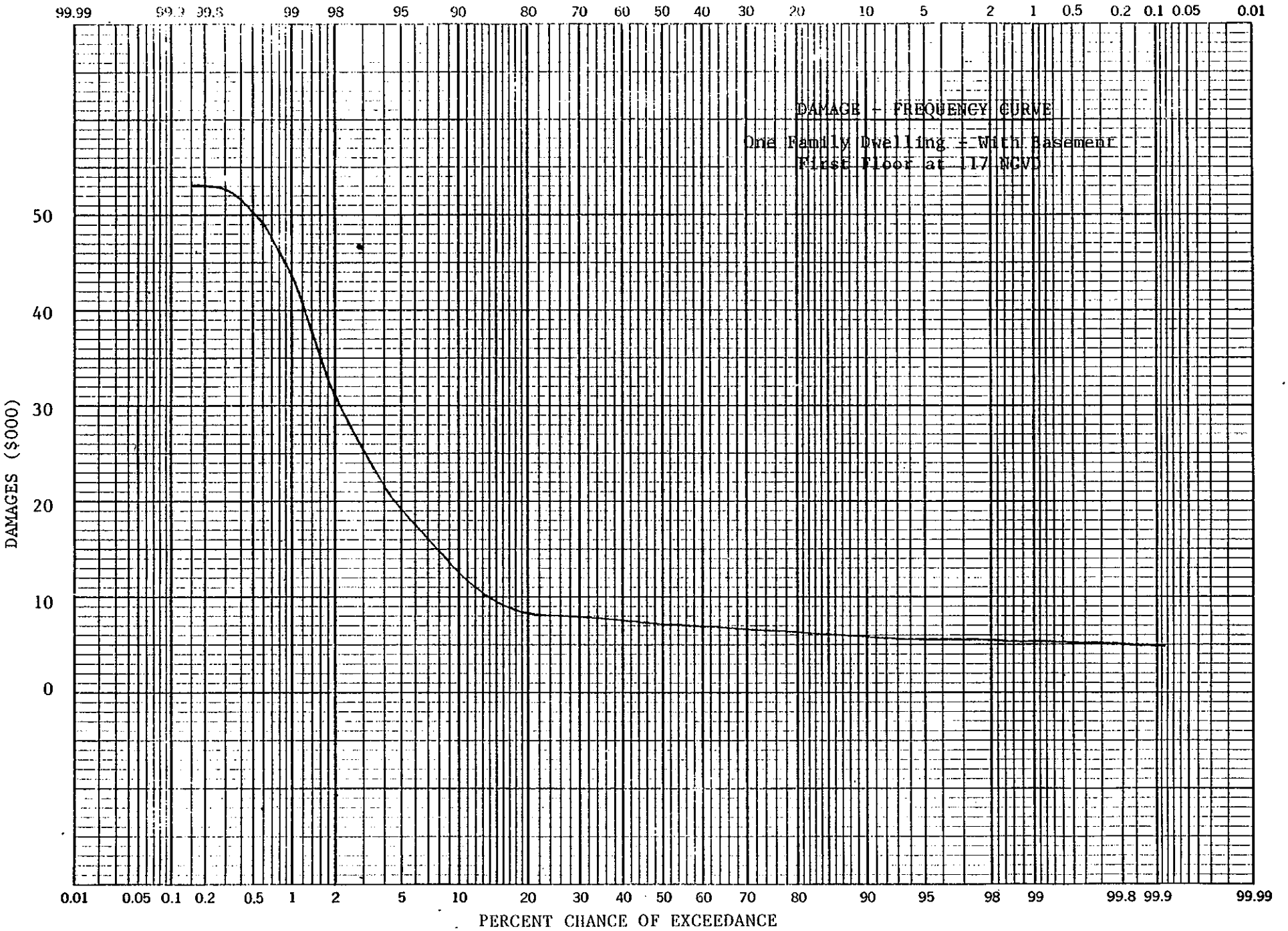
APPENDIX A



STAGE-DAMAGE CURVE

(0 Feet = First Floor Elevation


99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
122
120
118
116
114
112
110
108
106
104
ELEVATION, FEET NGVD
1936 HWM
1979 HWM
1938 HWM
STAGE-FREQUENCY
CONCORD RIVER
AT
REACH 2, BILLERICA, MA
ALTHOUGH SURVEYED ELEVATIONS ARE UNKNOWN, THE 1936 HWM IS BELIEVED TO BE WITHIN 0.5 FT. OF THE 1979 HWM.
PERCENT CHANCE OF EXCEEDANCE
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99


DAMAGE - FREQUENCY CURVE
One Family Dwelling - With Basement
First Floor at 17 NGVD
DAMAGES ($000)
50
40
30
20
10
0
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENT CHANCE OF EXCEEDANCE

TECHNICAL LITERATURE

Flood Emergency and Residential Repair Handbook. Federal Emergency Management Agency. Washington, D.C., U.S. Government Printing Office, March, 1986.

Reducing Losses in High Risk Flood Hazard Areas. Federal Emergency Management Agency. Washington, D.C., U.S. Government Printing Office, February, 1987.

Flood Proofing Systems & Techniques. U.S. Army Corps of Engineers, Office of Chief of Engineers. Washington, D.C., U.S. Government Printing Office, December, 1984.

Flood Proofing Tests. U.S. Army Corps of Engineers, Vicksburg District. August, 1988.

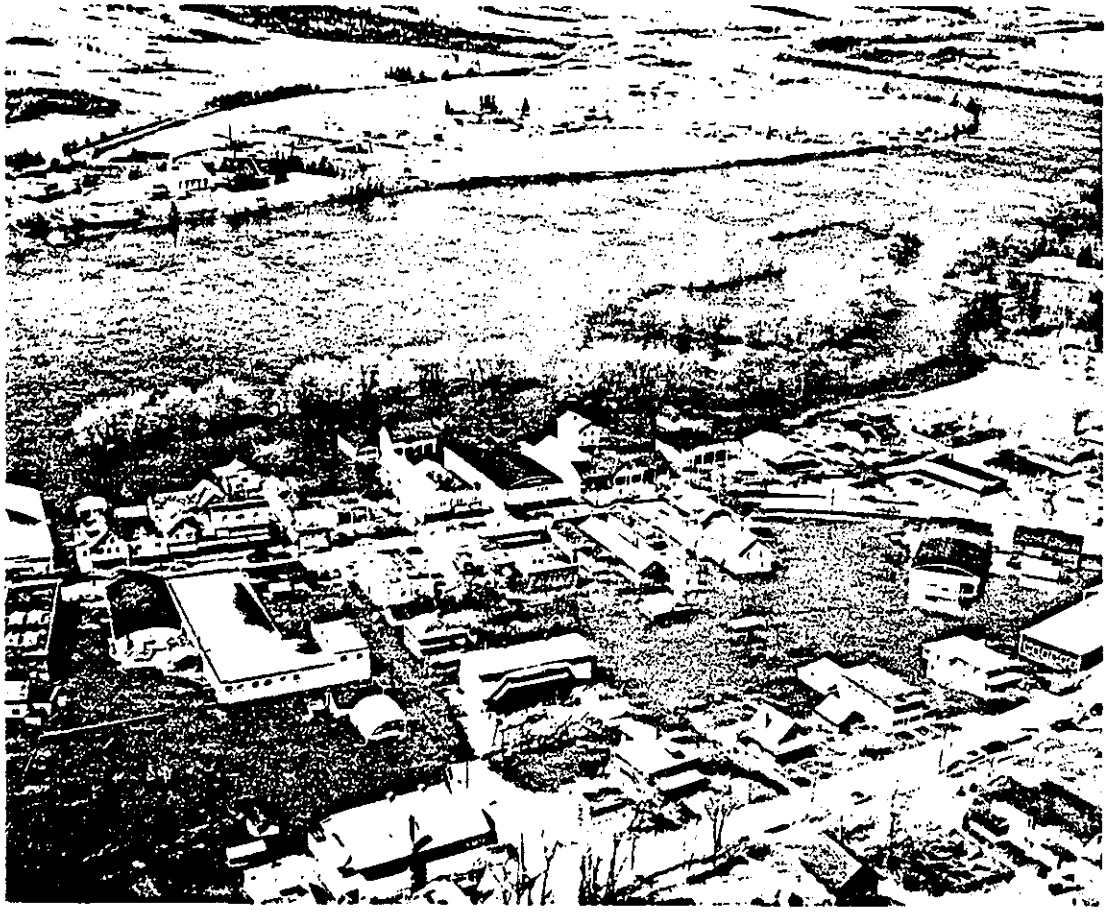
Cost Report on Non-Structural Flood Damage Reduction Measures for Residential Buildings Within the Baltimore District. U.S. Army Corps of Engineers, Baltimore District. Fort Belvoir, VA. U.S. Institute for Water Resources, 1977.

Comprehensive Flood Warning/Preparedness Studies. U.S. Army Corps of Engineers, October 1988.

APPENDIX B

FLOODPROOFING:
A GUIDE FOR PROPERTY OWNERS

SECTION 206: FLOOD PLAIN MANAGEMENT ASSISTANCE



United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

New England Division

FEBRUARY 1981

Contents

I AUTHORITY AND ACKNOWLEDGEMENTS

The authority for the preparation of this report is contained in Section 206 of the Flood Control Act of 1960 which authorizes the U.S. Army Corps of Engineers "...to compile and disseminate information on floods and flood damages...and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard."

This report has been published by the New England Division, U.S. Army Corps of Engineers, for use by private individuals in evaluating measures to reduce flood damage. It contains excerpts from a paper by Dr. James Dexter and from several previous Corps publications.

II PREFACE

The purpose of this report is to provide the individual property owner with information on various FLOODPROOFING options that can be implemented to reduce flood damages.

Floodproofing measures have limited ability to diminish flood losses, and the homeowner or businessperson should not be misled into thinking he or she has total flood protection. Particular care must be taken to insure that the perils of remaining in a flood threatened location are understood. Floodproofing can protect against property loss, but it should not be considered a protection against physical injury. Nevertheless, floodproofing in some situations can be used to effectively reduce losses from flooding, and in those cases it should be fully evaluated as an option available to the homeowner and businessperson.

III FLOOD DAMAGE PREVENTION

In the overall context of flood damage prevention, measures for reducing or preventing damages can be divided into corrective and preventive measures (Figure 1). Reservoirs, levees, channel improvements and watershed treatment are types of flood control measures aimed at keeping floodwaters within established channel banks or floodway limits and are characterized as corrective measures. Land use controls, commonly known as "Flood Plain Regulations," comprise those measures of floodway designation, encroachment lines, zoning, subdivision regulation and building codes that can be used to lessen the damaging effects of floods on future or potential development. They are characterized as preventive measures.

The measures themselves are implemented at every level of government — Federal, State, regional and local — as well as by the individual. The focus of this guide is on floodproofing with information geared toward the individual homeowner or businessperson.

IV WHAT IS FLOODPROOFING

Floodproofing means making a building and its contents more resistant to flood damage. It can reduce flood damage and make occupation of flood hazard areas more bearable.

Unless the protection level is exceeded, floodprooofing a structure will:

- Reduce the frustration of cleaning up after floods.
- Provide a reward in the form of less damage and repair cost over a long period of time.
- Cost less than you think, in some cases.
- Offer an additional tool in a comprehensive flood damage reduction program.
- Increase the protection afforded by partial protection flood control projects.
- Possibly improve the cost of flood insurance.
- Increase interest in flood damage reduction programs by heightening the awareness of flood risk.

Floodproofing a house will not:

- Be effective for large floods that exceed the design level.
- Solve all problems caused by floods.
- Provide for occupancy of buildings during floods, in most cases.

Floodproofing is not a cure for all flood problems. Rather, it should be considered one device among many available flood damage reduction measures, including land use regulation and change, flood control projects, flood fighting, flood relief and flood insurance. A comprehensive flood plain management program would ordinarily include the use of several or all of these techniques.

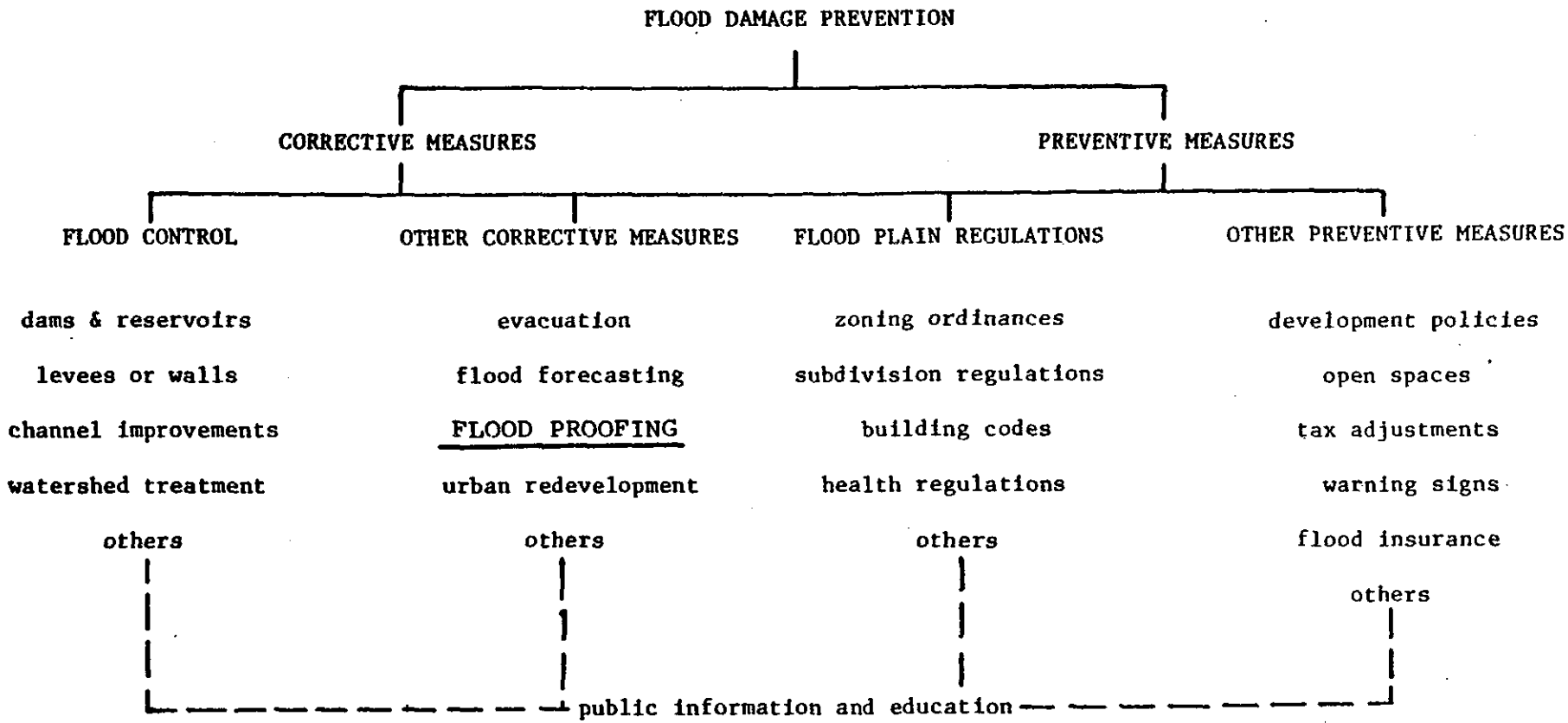

FLOOD DAMAGE PREVENTION
CORRECTIVE MEASURES
PREVENTIVE MEASURES
FLOOD CONTROL
OTHER CORRECTIVE MEASURES
FLOOD PLAIN REGULATIONS
OTHER PREVENTIVE MEASURES
dams & reservoirs
levees or walls
channel improvements
watershed treatment
others
evacuation
flood forecasting
FLOOD PROOFING
urban redevelopment
others
zoning ordinances
subdivision regulations
building codes
health regulations
others
development policies
open spaces
tax adjustments
warning signs
flood insurance
others
public information and education

FIGURE 1

V THINGS YOU SHOULD KNOW BEFORE YOU BEGIN

Flood Elevations

There are several sources of information on flood heights:

- The Federal Emergency Management Agency (formerly Federal Insurance Administration) prepares the official "Flood Insurance Rate Maps" and "Flood Hazard Boundary Maps." Individuals can use these maps to determine flood elevations along most major streams.

- The Corps of Engineers and other Federal agencies have completed studies for selected flood hazard areas. These studies include flood elevations. The Flood Plain Management Section, New England Division, U.S. Army Corps of Engineers maintains a record of where the most recent Federal information on flood elevations can be found.

- State, regional or local governments may also have some flood information.

Lowest Floor Elevation of Your Building

A professional land surveyor can determine the lowest floor (including the basement) elevation of your building.

Comparing Flood and Floor Elevations

To determine the extent of the flood hazard at your building, simply subtract the floor elevation from the flood elevation. This will tell you the expected depth of water at your first floor for a particular flood frequency (Figure 2).

Note: Flood elevations are generally referenced to the National Geodetic Vertical Datum (NGVD) formerly known as Mean Sea Level of 1929 (MSL). BE CERTAIN THAT YOUR BUILDING ELEVATIONS ARE REFERENCED TO THE SAME DATUM — NGVD.

Flood Frequency Information

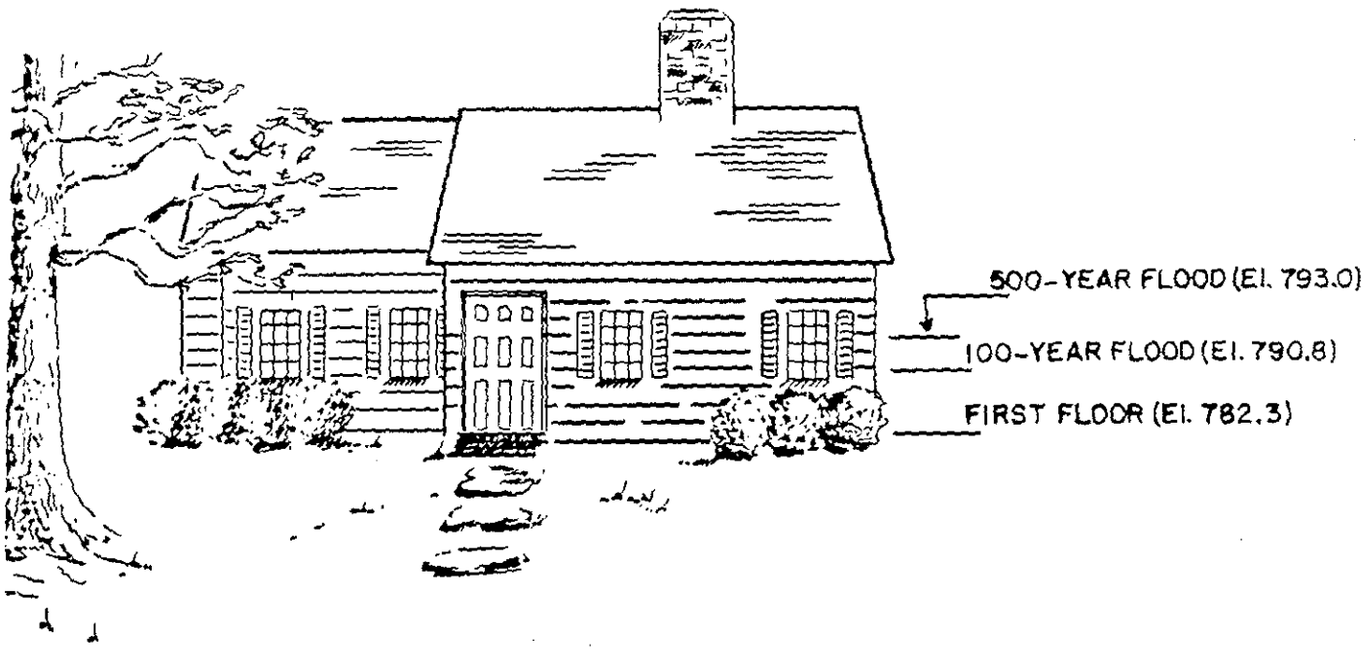
Generally flood elevations refer to a flood frequency. It is important to understand the concept of flood frequency before decisions on investments in floodproofing are made.

When you read a flood information report, you will find that hydrologists discuss various frequency floods (i.e., 50-year flood, 100-year flood, 500-year flood). To simplify this terminology, use the following table to get an indication of the chance that a given flood will be equaled or exceeded in any year:

Flood Frequency	Chance That The Flood Will Be Equaled or Exceeded in Any Year
500-year	0.2%
100-year	1%
50-year	2%
10-year	10%
5-year	20%

Flood frequency computations are based on records of floods that have occurred in the area over a long period of time. Remember, these computations show long run averages. You can have 100-year floods 2 years in a row or even in the same year!

You can use flood frequency data to compute your chances of being flooded. For example, suppose the first floor of your building, is at elevation 875.0 NGVD and the elevation of the 5-year flood is 875.0 NGVD. You then have a 20 percent chance of a flood reaching your first floor during any year.



NOTE : ALL ELEVATIONS
REFERENCED TO
NGVD

COMPARE FLOOD AND FLOOR ELEVATIONS

FIGURE 1

VI BE PREPARED FOR THE WORST

A floodproofing plan will not necessarily prove adequate for a very large flood. Thus, a dangerous situation can develop if you are not prepared for this possibility. The following are actions you can take to prepare for a catastrophic flood:

- First, any floodproofing package you use should have a "safety valve" in case its maximum effectiveness is exceeded. This should be designed to permit flooding to occur at the maximum floodproofed level with a minimal destructive force. For example, a floodwall or dike should have an overflow area where water can spill safely into the protected area.

- Second, plan ahead on how contents can be moved to higher levels of the building if it appears your first line of defense, such as floodwall, will be overtopped.

- Third, make sure you have an escape route if the flood depth becomes dangerous, and leave ample time to use it. Preplan with your family or employees to leave the structure when floodwaters reach a specific level. Remember, it is better to leave too soon safely than to wait and find yourself stranded. Surrounding roads may flood out sooner than the area around your building.

- Fourth, purchase and use a radio that receives the National Oceanic and Atmospheric Administration (NOAA) weather radio broadcast. NOAA broadcasts weather reports on three frequencies: 162.400 MHz, 162.475 MHz and 162.550 MHz (see below for a list of New England broadcast centers and their frequencies).

- Finally, keep your flood insurance policy active.

NATIONAL OCEANIC AND ATMOSPHERIC
ADMINISTRATION BROADCAST FREQUENCIES

Broadcast Center	Frequency (MHz)
Hartford, Connecticut	162.475
Meriden, Connecticut	162.400
New London, Connecticut	162.550
Ellsworth, Maine	162.400
Portland, Maine	162.550
Boston, Massachusetts	162.475
Hyannis, Massachusetts	162.550
Concord, New Hampshire	162.400
Providence, Rhode Island	162.400
Burlington, Vermont	162.400
Brattleboro, Vermont	162.475

VII FLOODPROOFING OPTIONS FOR THE PROPERTY OWNER

Floodproofing Measures

Floodproofing measures can be classified into three broad categories. First, are permanent measures which become an integral part of the structure or land surrounding it. Second, are temporary or standby measures that are used only during floods, but are constructed and made ready prior to any flood threat. Third, are emergency measures that are carried out during flood situations in accordance with a predetermined plan.

Only the first two types of measures will be discussed in the following sections, which will focus on their use in existing structures located in flood hazard areas.

Individual Analysis

It is possible to significantly reduce damages and save on repair bills even if your structure is flooded only once. You can install some of the floodproofing measures discussed in this report by yourself, or with minimal help, by relying on your previous experience with floods. Most measures, however, require help from a professional engineer and/or a building contractor.

Cost estimates for floodproofing measures are provided for each floodproofing method discussed. IT SHOULD BE UNDERSTOOD THAT THE COSTS ARE ESTIMATES AND THAT YOUR COSTS MAY VARY. Dollar figures in this report are referenced to December 1980 prices.

The costs and savings for your building depend on:

- Your exposure to floods.
- The size and type of your building.
- The way you use the parts of the structure exposed to floods.

The following pages outline five basic floodproofing methods:

1. Rearranging or protecting damageable property within an existing structure.
2. Installing temporary or permanent closures for openings in existing structures.
3. Constructing small walls or dikes around existing structures.
4. Raising existing structures in place.
5. Relocating existing structures and/or contents out of a flood hazard area.

Many of these measures are equally applicable to protection of new structures or can be implemented when making major improvements (see Section VIII, "Construction Improvements to Existing Structures," for a summary).

Local, State and Federal regulations pertaining to modifications in the flood plain and streambed may require permits before construction. Check with your local government and other regulatory bodies to insure that you fulfill all permit and/or building code requirements.

Some nonstructural measures, such as flood shields for doorways and windows, gates for openings in walls or dikes, and evacuation of people and property, require warning time to implement. The reliability of protection provided by measures that require warning is obviously less than those that require no warning. In fact, lead time may mean the difference between protection and no protection.

METHOD 1

REARRANGING OR PROTECTING DAMAGEABLE PROPERTY WITHIN AN EXISTING STRUCTURE

Method 1 minimizes the way water comes in contact with damageable items. It can involve either minor or major modifications to the structure, selecting specific types of contents, and taking preparatory, emergency and cleanup actions (Figures 3-5). Actions to be taken under Method 1 are listed in Table 1. Many items in this package can be accomplished by the property owner with minimal outside help. A disadvantage is that water will still enter the building and cause damage to the structure and unprotected contents.

Residential Applications

Some measures in Method 1 can be easily and cheaply implemented by the property owner. The rearrangement or raising in place of contents within a structure is easily accomplished and can result in significant savings should a flood occur. Utility cells and rooms, while effective floodproofing measures, are expensive and require professional expertise. Because of the expense involved, utility cells and rooms are applicable only to those property owners who experience high flood damages.

Commercial and Industrial Applications

The rearrangement or raising in place of contents within a structure is equally applicable to commercial and industrial structures. Cells, elevated rooms or interior floodwalls may be more feasible for commercial industrial structures because of the generally high cost of repair or replacement of their mechanical equipment.

Physical Feasibility

The degree to which property can be rearranged and protected is site specific. It depends on the flood hazard, principally depth and frequency of flooding, and the damageable property and its type, value, location and mobility. Shallow flooding allows the use of protective types of measures where appliances, utilities, equipment, and goods can be raised in place, surrounded, or enclosed and protected. Where the hazard is more severe and inundation is to greater depths, property will need to be relocated to prevent damage.

Residual damage to both structure and contents will remain even when property is rearranged or protected. For this reason, protection of property seems to be given most serious consideration when other measures are either not physically or economically feasible, or the depth of flooding is relatively shallow.

TABLE 1
REARRANGING OR PROTECTING DAMAGEABLE PROPERTY
WITHIN AN EXISTING STRUCTURE

Actions for Utilities and Equipment

1. a) Raise the hot water heater, air conditioner, furnace and appliances (washers, refrigerators, etc.) onto concrete blocks or platforms.
   b) Relocate utility area (usually a separate room) to elevation above flood elevation.
   c) Construct watertight cell around utilities at their present location.
   d) Construct interior floodwalls around critical equipment.
2. Provide drains in the heating and air conditioning ducts below expected flood levels so they will not collapse under the weight of retained water as the flood recedes.
3. Raise all electrical receptacles or put them on branch circuits separate from overhead lighting.
4. Install a manual sewer cutoff valve outside the structure.
5. Finished basement ceilings should have clearances between moldings and walls to permit drainage of retained water.

Actions for Contents

1. All cabinetry should be raised or made from metal to be water damage resistant.
2. Carpeting and carpet cushions should be of an outdoor type, manufactured from materials that can withstand immersion in water. Salvage is more economical than replacement. Finished flooring materials should be water damage resistant and adhesives should be stable after immersion.
3. Paints and applied finishes should be water damage resistant brands, which will remain serviceable and attractive after surface washing.

Preparatory Actions

1. Tune your radio to a station that broadcasts National Oceanic and Atmospheric Administration weather reports (see page 5).
2. Do not store damageable items in low areas, if possible.
3. PREPARE A LIST OF THINGS TO DO to be implemented as soon as you hear a general flood warning broadcast:
   a) move cars to higher ground.
   b) secure lawn furniture and tools.
   c) stack sandbags around openings to give you extra time to move things.
   d) unhinge interior doors to make tables for stacking posessions.
   e) roll up small rugs.
   f) move lighter posessions to a safe place such as an attic.

Emergency Actions

1. In the event you notice water rising quickly, HAVE A PRE-ARRANGED PLAN:
   a) turn off utilities.
   b) use a hand truck to move heavy appliances such as washing machines to higher floors or higher ground.
   c) stack furniture on concrete blocks; use doors laid on blocks as tables to stack drawers, lamps, clothing, photos, etc.
   d) roll up rugs, tie up curtains and draperies.
2. HAVE A PRE-ARRANGED ESCAPE ROUTE IF THE WATER SHOULD GET DANGEROUSLY HIGH AND ALLOW YOURSELF ENOUGH TIME TO USE IT BEFORE IT IS CUT OFF.

Advantages

. Almost every property owner can implement this method to one degree or another.

. It can be done on a per item basis, thus reducing the cost and allowing selective protection of high value contents.

. A structure can continue to be used at its existing site.

Disadvantages

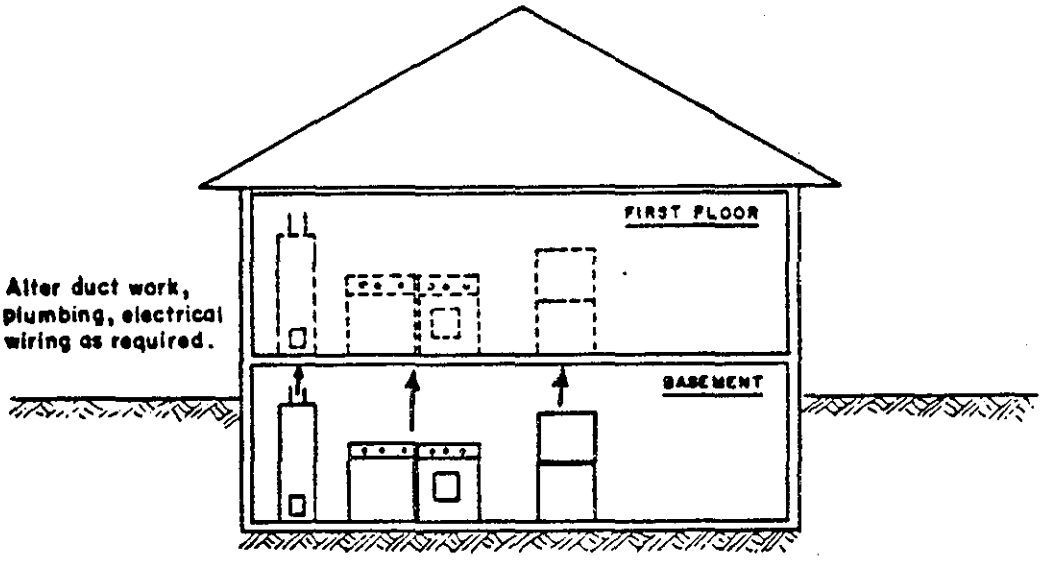
. Damage can be reduced only on those items that can be relocated or protected.

Economic Feasibility

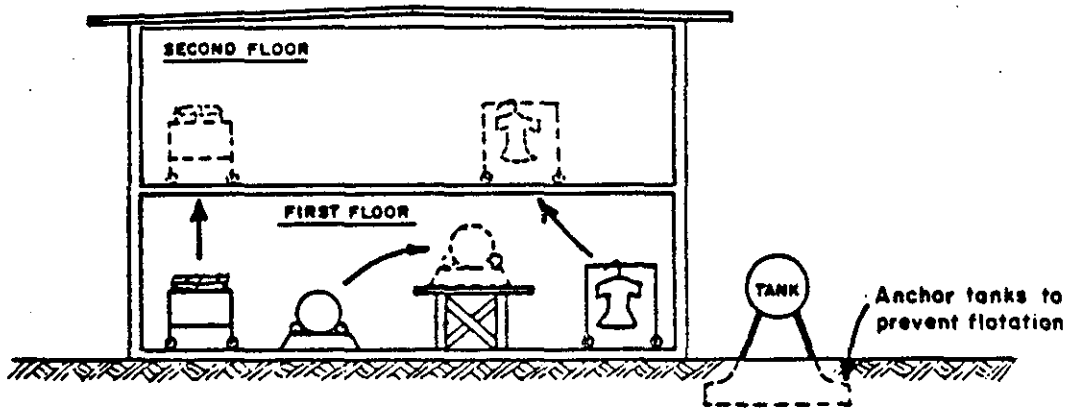
When damageable property is rearranged or protected within a structure, damage is reduced because the property is less susceptible to flooding. Because this type of measure deals principally with individual property items, an assessment should probably be made that considers the cost to relocate or protect, the damage caused by flooding, the frequency of flooding, the inconvenience, and the availability of alternative locations.

Although many of the actions are relatively inexpensive, protection of utilities such as the furnace and electrical box can be costly. For example, cost estimates for constructing utility cells or rooms of a type shown in Figures 4 and 5 are:

	Estimated Total Cost
Utility Cell	$13,700
Utility Room	$8,000



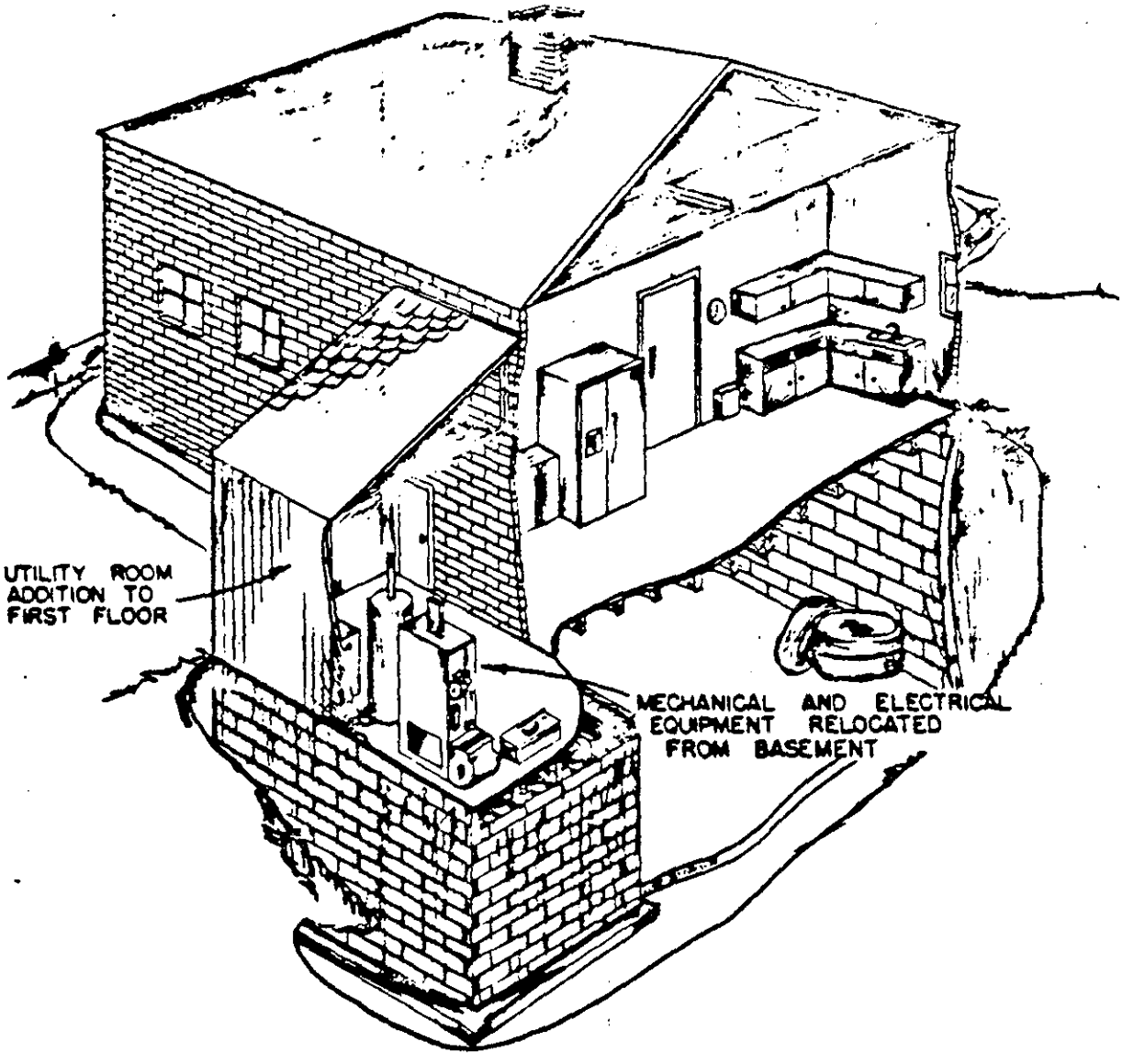
Raise Furnace, Water Heater, Washer, Dryer to First Floor



Raise and Relocate Merchandise and Equipment, Anchor Floatable Items.

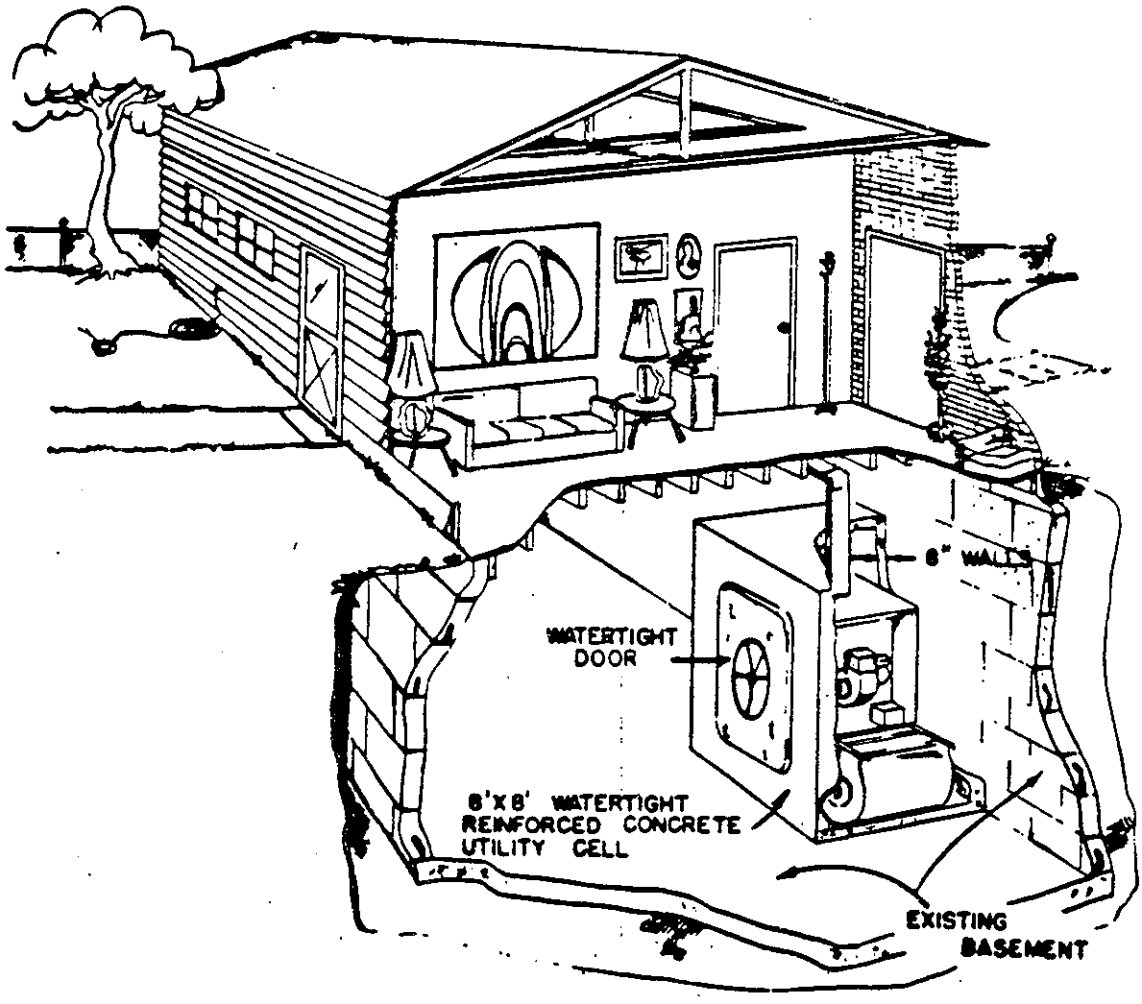
Rearranging or Protecting Existing Property

FIGURE 3



RELOCATION OF HOUSEHOLD MECHANICAL
AND ELECTRICAL EQUIPMENT TO FIRST FLOOR

FIGURE



Protection of Existing Utility Equipment

FIGURE

TABLE 2

TEMPORARY AND/OR PERMANENT CLOSURES

ACTIONS

1. Floodproof sewer lines and other plumbing facilities by the installation of backflow valves

2. Have on hand and in good working order all equipment necessary for installation of flood shields (tools, nuts, bolts, etc.). Flood shields are normally fabricated of aluminum, steel or wood. These shields should be no higher than 2 feet so that water pressure will not cause structural damage (shields could be higher for some commercial or industrial buildings). They should be stored nearby for installation during a time of flooding.

3. Place sandbags over the flood shield to insure its effectiveness.

4. Permanently close nonessential openings with masonry or other relatively impermeable materials.

5. Install sump pumps to remove any seepage that is likely to enter the structure even though it has been made generally watertight. The pump discharge must be installed above the expected level of flooding.

CAUTIONS

1. THIS METHOD WILL NOT WORK FOR FLOOD DEPTHS GREATER THAN 2 FEET. PROVIDE FOR OVERFLOW INTO HOUSE AT THIS DEPTH. GREATER DEPTHS CAN CAUSE SEVERE STRUCTURAL DAMAGE TO WALLS AND DOORS. Commercial and industrial structures may be able to withstand greater flood depths.

2. Basement or exterior walls must be essentially impermeable, not usable if exterior is wood siding.

3. A sump pump is needed to collect infiltration. Be sure it's heavy duty — 1/2 horsepower or larger.

4. A good alarm system is needed to alert you of floods at night or during off business hours to insure enough time to install shields. Cooperate with your neighbors to warn each other of floods and to help each other install shields. Show them how to install shields before you go on vacation.

5. Brick veneer may need reinforcing.

6. CHECK TO INSURE THE STRUCTURE IS PROPERLY ANCHORED TO THE FOUNDATION. OTHERWISE, THE BUILDING MAY FLOAT.

METHOD 2

INSTALLING TEMPORARY AND/OR PERMANENT CLOSURES

Structures whose exterior is relatively impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows as shown on Figure 6. Due to the hydrostatic and buoyant pressures floodwaters exert on the building's walls and basement, this method is better suited for commercial and industrial structures that are more structurally sound. While some seepage will probably always occur, it can be reduced by applying sealants to walls and floors and providing floor drains where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and therefore need warning time before installation. Specific measures that may be undertaken are described in Table 2.

Residential Applications

Due to buoyant and hydrostatic pressures, closures are not recommended for most residential structures that are not normally designed to withstand such loads. A second drawback is the possibility of incurring flood damage in the event a closure is neglected or fails to function as intended due to improper placement.

Commercial and Industrial Applications

Generally, closures are better suited to commercial and industrial structures that may be capable of withstanding buoyant and hydrostatic pressures. Permanent masonry closures have been effective in preventing flood damages at many industrial riverine sites in New England.

Physical Feasibility

Most structures, whether residential, commercial or industrial, are not designed to withstand hydrostatic pressure on the exterior walls. Therefore, when discussing physical feasibility, the principal considerations are that, 1) the exterior walls are impermeable or can be made so, 2) all openings below the design level can be closed, and 3) THE STRUCTURE CAN WITHSTAND THE ANTICIPATED HYDROSTATIC PRESSURES INCLUDING BUOYANT.

When water is prevented from entering a structure, the walls become subject to lateral and hydrostatic forces that may cause failure, and the basement floor is subject to uplift forces that may cause buckling or flotation. Most structures are not designed to carry these forces and consequently are in danger of collapse or floating if floodwaters rise too high. It is particularly difficult to analyze the capability of existing structures to resist these forces because of the general lack of knowledge about workmanship and materials used during construction and the present condition of these materials. As a result, it is recommended that the property owner seek advice from an engineer or architect regarding the feasibility of these measures before implementation.

Advantages

- May be done on a selective basis to only those openings through which water enters and only to the height desired.
- Easy and quick to implement.

Disadvantages

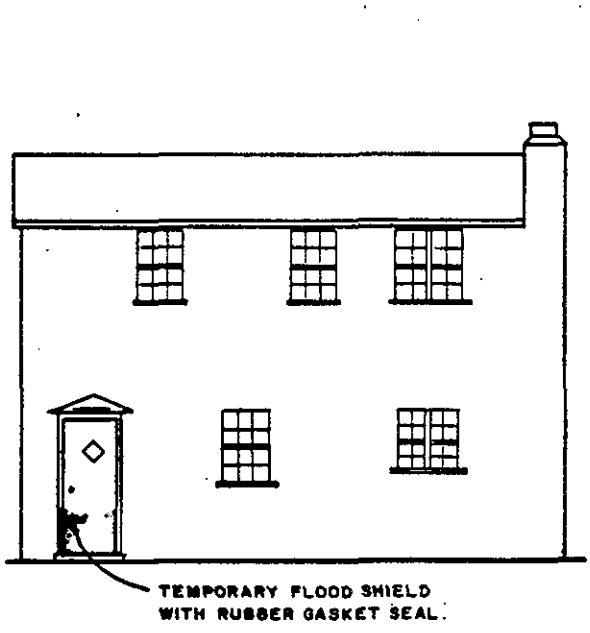
- In the case of residential structures, is applicable only to those with brick or masonry type walls, without basements, which can structurally withstand the hydrostatic and uplift pressure of the design flood, and which are generally watertight. This disadvantage also applies to commercial and industrial structures, except that the walls and basements may be capable of withstanding greater pressures.
- Reduced likelihood of effective implementation at night, and during vacations and off-business hours.
- May create a false sense of security and induce people to stay in the structure longer than they should.

Economic Feasibility

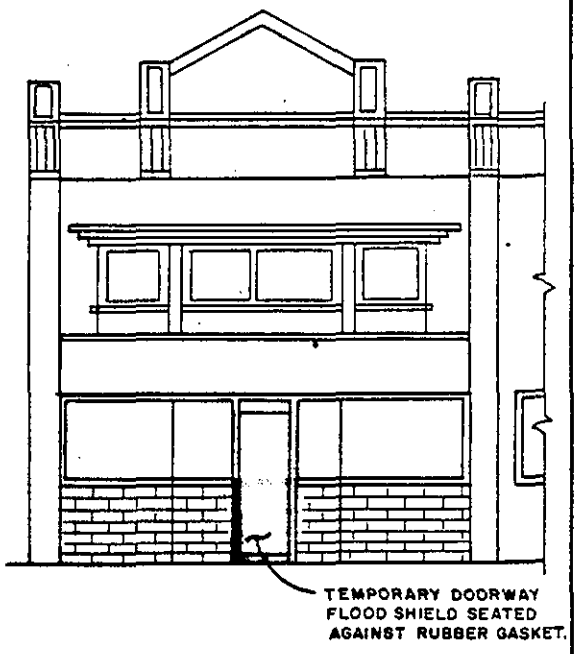
When floodwater is prevented from entering a structure, damage is reduced up to the design level of the protection provided. When a flood exceeds the protection level, damage occurs as it normally would without protection. The damage reduced includes damage to contents and structure interior. Damage to structure exterior and the site still remain. Cost estimates for this type of floodproofing measure are as follows:

	Estimated Cost
Flood Shields (3-3'x2' aluminum, installed)	$1,380
Sewer Gate Valve	430
Total Cost	$1,810

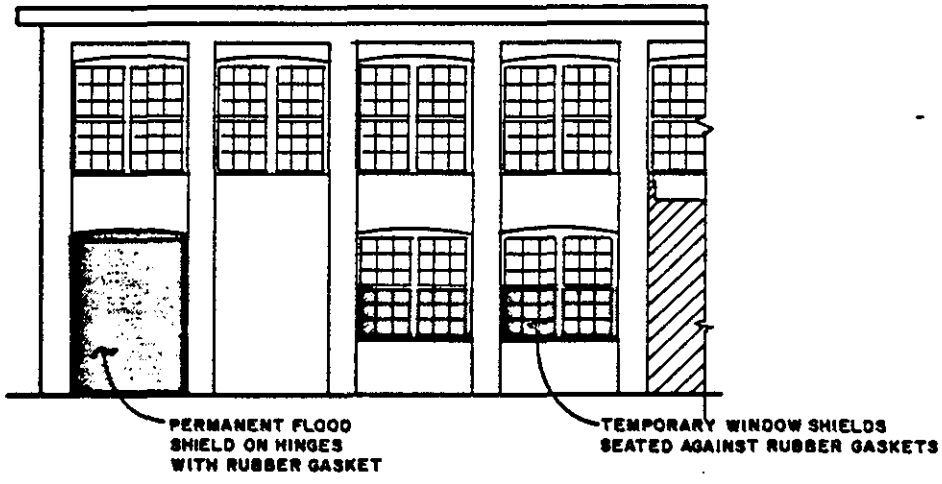
Estimated for a $30,000, 1,600 square foot structure with front, rear, and side entrances. Closure to 2 feet above first floor. Costs include 25 percent for contractor's bonds, overhead, profit and engineering.



TWO STORY BRICK
RESIDENTIAL STRUCTURE



ROW STRUCTURE



COMMERCIAL / INDUSTRIAL STRUCTURE

Temporary and Permanent Closures

FIGURE

METHOD 3

CONSTRUCTING SMALL WALLS OR DIKES

Method 3 minimizes the ways in which water can reach your home. It requires constructing walls or dikes (Figure 7). Walls and dikes are designed to protect one or several structures (see Table 3 for specific actions), and are built to be compatible with local landscape and aesthetics as shown in Figure 8. Walls may be of various masonry materials designed to resist the lateral and uplift pressures associated with flooding. Levees or dikes are usually constructed with an impervious inner core to prevent seepage and with slope protection where erosion is a problem. Where access openings are necessary, provisions must be made to close these openings during floods. This generally means providing a floodgate that can either be stored at the opening and installed when needed, or constructing it on hinges or rollers for automatic or semiautomatic closure.

During flood conditions it is possible for precipitation, seepage and runoff from roof drainage to cause water to accumulate inside a wall or dike and cause water damage to the property being protected. This problem can be reduced by providing interior drainage facilities to remove the water. Generally, this includes construction of a low-lying sump area to collect the drainage and a pump to remove it. As part of the interior drainage facilities, backup can be prevented by installation of appropriate valves in discharge lines. It is important that a professional engineer design this package, as the hydrostatic and hydrodynamic loadings may be greater than envisioned by the layman.

Residential Applications

Walls and dikes are effective in preventing damages, but are expensive and require professional assistance. Aesthetics and the amount of surrounding land area, especially in more urban areas, can also create problems for the property owner. Because it is a large and expensive undertaking, it is applicable only to those property owners who experience high flood damages.

Commercial and Industrial Applications

Where flood damages are high, walls and dikes are recommended for commercial and industrial structures, where aesthetics can be less restrictive.

Physical Feasibility

One particular advantage of a wall or dike is that it is not limited to a particular type or size of structure and therefore is feasible for any residential, commercial or industrial property. The question of physical feasibility centers on site conditions such as topography, available space and compatibility with existing use, and on the nature of flooding velocity and location relative to the structure being protected.

TABLE 3

SMALL WALLS AND DIKES

ACTIONS		CAUTIONS
WALLS	**DIKES**	
1. Construct reinforced block or stone wall, and footing.	1. Construct compacted earth fill dike with impervious core and seepage drains.	1. Architect-Engineering firm should be contacted to develop the plans.
2. Install internal drainage system including tile networks for underseepage, gravity drians, sump pump and other underground utilities.	2. Install internal drainage system including tile networks, gravity drains, sump pump and cutoffs for sewer and other underground utilities.	2. Wall height is generally limited to 6 to 8 feet. Provide overflow area protected from erosion.
3. Provide for openings for egress; protected by flood gates or removable flood shields.	3. Provide for overflow area or relief valve to permit floods higher than the design to enter the enclosed area safely without structural damage.	3. Access openings may be required. You will need to have warning to complete a closure or use manual gates.
4. Provide for overflow area or relief valve to permit floodwaters higher than the design to enter the enclosed area safely without structural damage to the house.		4. Permission to build in the flood plain may be necessary. Check with your local zoning commission and State and Federal regulatory agencies.
		5. An inadequate design may result in a greater damage than would have occurred without the wall or dike.

Advantages

- Not dependent upon the site, type or condition of property being protected.
- Protects property outside a structure.
- Can be aesthetically pleasing and provide privacy and security in addition to flood protection.

Disadvantages

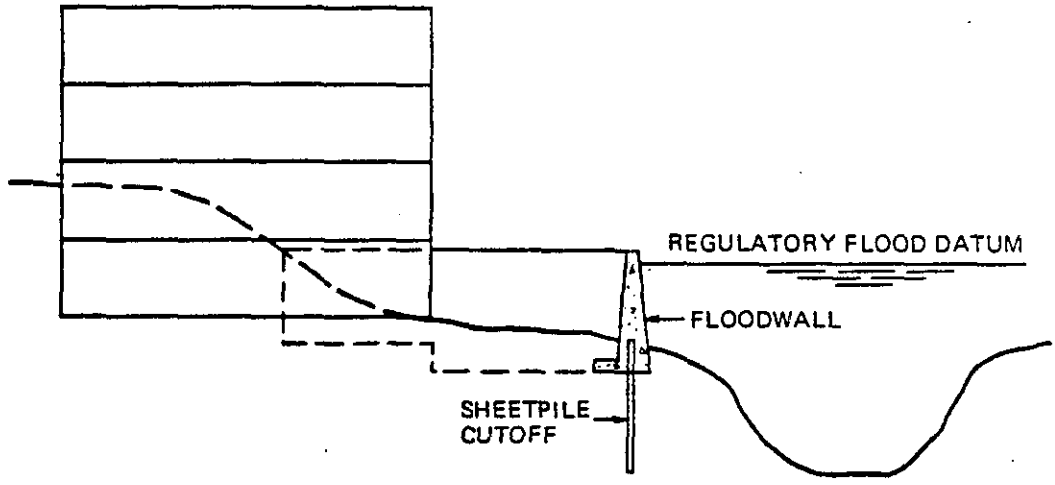
- Dependent upon site conditions: topography, property lines, available space, soil and ground water conditions, velocity and depth of flooding, and location of floodwater relative to structure.
- May require access openings which must be closed during a flood. If the closures are manual, a warning time is necessary.

Economic Feasibility

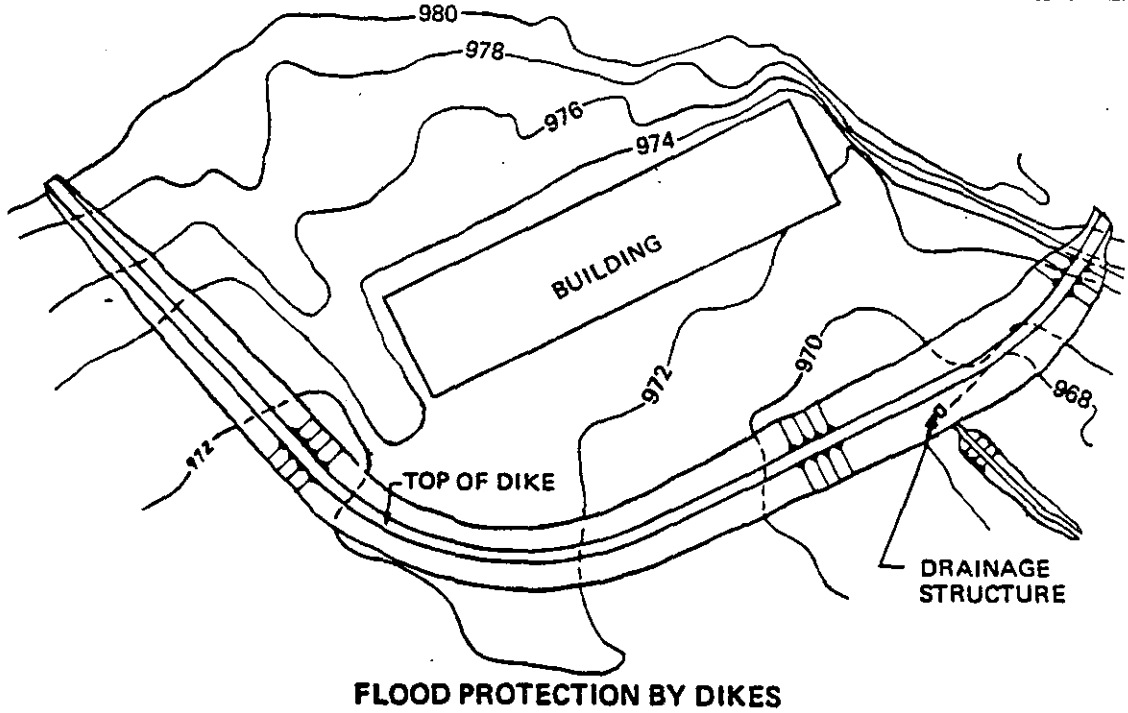
A small wall or dike will prevent damage to both structure and contents. Damage is prevented up to the design height of the wall or dike. Costs are as follows:

Item	Estimated Cost			
	Wall		Levee	
	3 feet	5 feet	3 Feet	5 Feet
Construct Wall or Levee	$4540	$6910	$1130	$2260
Provide Sump Pump	1340	1340	1340	1340
Install Sewer Gate Valve	430	430	430	430
Total First Cost	$6300	$8680	$2900	$4030

Estimated for a 1,600 square foot, $30,000 structure with or without basement. Protection assumed along backside of lot—140 feet for a wall and 216 feet for a levee. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.

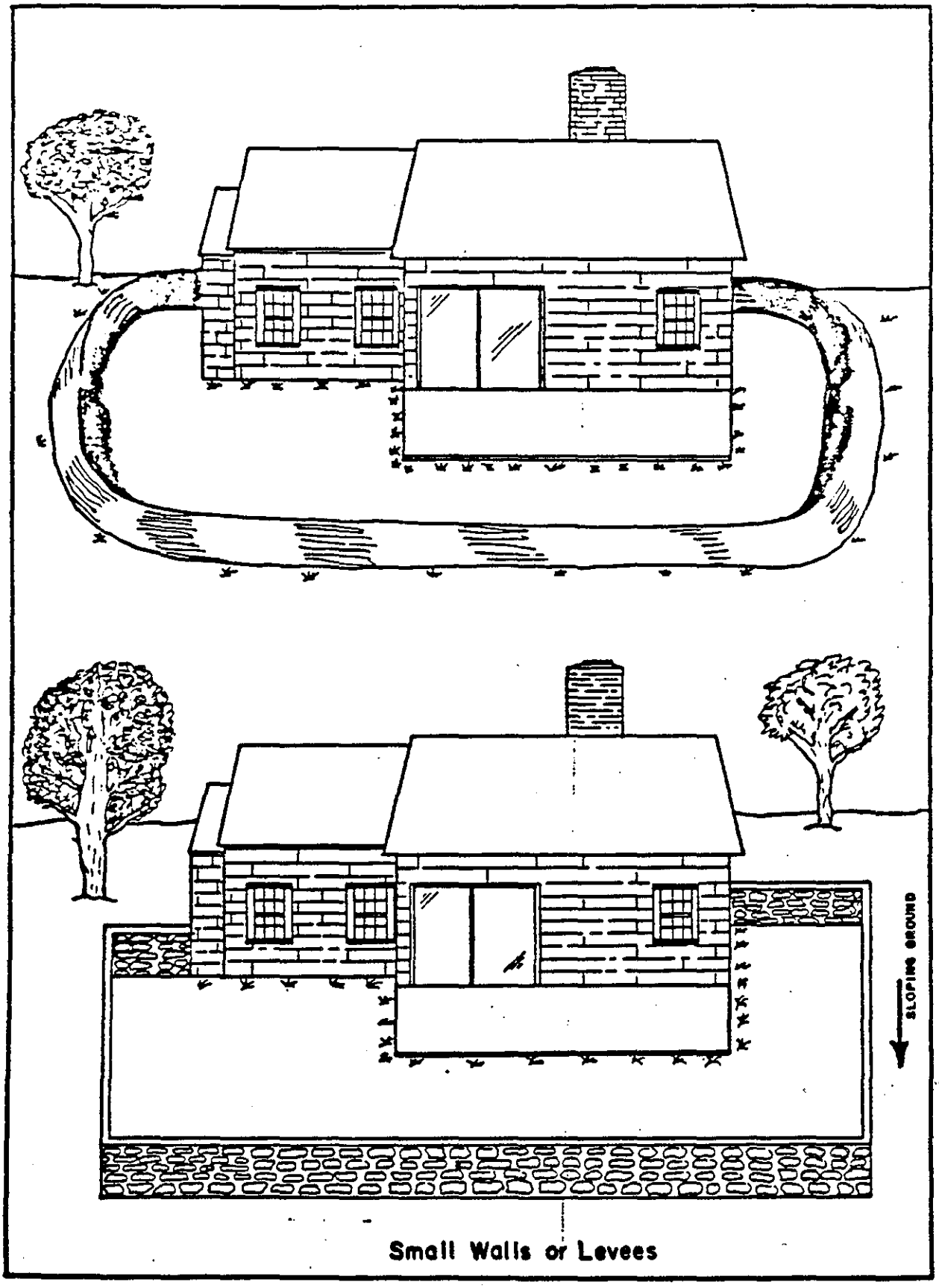


FLOOD PROTECTION WITH FLOODWALLS



FLOOD PROTECTION BY DIKES

FIGURE



Small Walls or Levees

FIGURE 8

METHOD 4

RAISING EXISTING STRUCTURE

Method 4 involves raising the structure above expected flood levels (Figure 9). In this method the building is raised on jacks by a professional mover and a new foundation is built and/or the lot is regraded to provide higher ground under the structure (see Table 4 for specific actions). The floodproofing method is not complete unless the building is evacuated during the early stages of a flood. Otherwise, people may become trapped inside and be in extreme danger should a catastrophic flood occur.

Residential Applications

The cost of raising a structure is the only serious drawback of this measure. Aesthetics and compatability with neighboring homes can be maintained by landscaping or applying adornments such as lattice work, to the area below the first floor. The expense of this method including professional assistance makes it applicable only to those homeowners who experienced high flood damages.

Commercial and Industrial Applications

Due to the size and usage requirements of most commercial and industrial structures, raising may not be physically feasible. The expense of raising a structure, assuming that raising is physically feasible, makes it an alternative to be considered only at those sites that experience high flood damages.

Physical Feasibility

Technology exists to raise almost any structure, however, raising-in-place from a practical viewpoint is most applicable to structures that can be raised by low-cost conventional means. Generally, this means structures that, 1) are accessible below the first floor level, 2) are light enough to be raised with conventional housemoving equipment, and 3) do not need to be partitioned prior to raising. Wood frame residential and light commercial structures with first floors above grade are particularly suited for raising. Structures with concrete floor slabs (slab-on-grade) and structures with common walls are not feasible to raise without special equipment involving additional expense.

Advantages

- Damage to structure and contents is reduced for floods below the raised first floor elevation.
- Particularly applicable to single and two-story frame structures on raised foundations.
- Structures have been raised to heights of up to 9 feet. Aesthetically, the greater heights are probably most acceptable in wooded areas of steep topography.

TABLE 4

RAISING THE STRUCTURE

Actions	Cautions
1. Unhooking, modifying, and re-hooking utilities	1. Generally limited to 8 to 10 feet above feet above present level.
2. Raising the structure.	2. Building permits may be needed - plan to spend a couple of months securing an architect or contractor and obtaining permits.
3. Constructing a new foundation and anchoring the house frame to it.	3. Occupants should evacuate the house when a flood is forecast. Otherwise, they may become stranded. Should the flood be larger than anticipated, the occupants lives would be in jeopardy.
4. Landscaping and architectural treatment of the new exterior.	

- The means of raising a structure are well known and contractors are readily available.

- Raising-in-place allows the user-owner to continue operations at the existing location.

Disadvantages

- Residual damages exist when floods exceed the raised first floor elevation. Minor damage may occur below the first flood depending upon use.

- Not generally feasible for structures with slab-on-grade foundations.

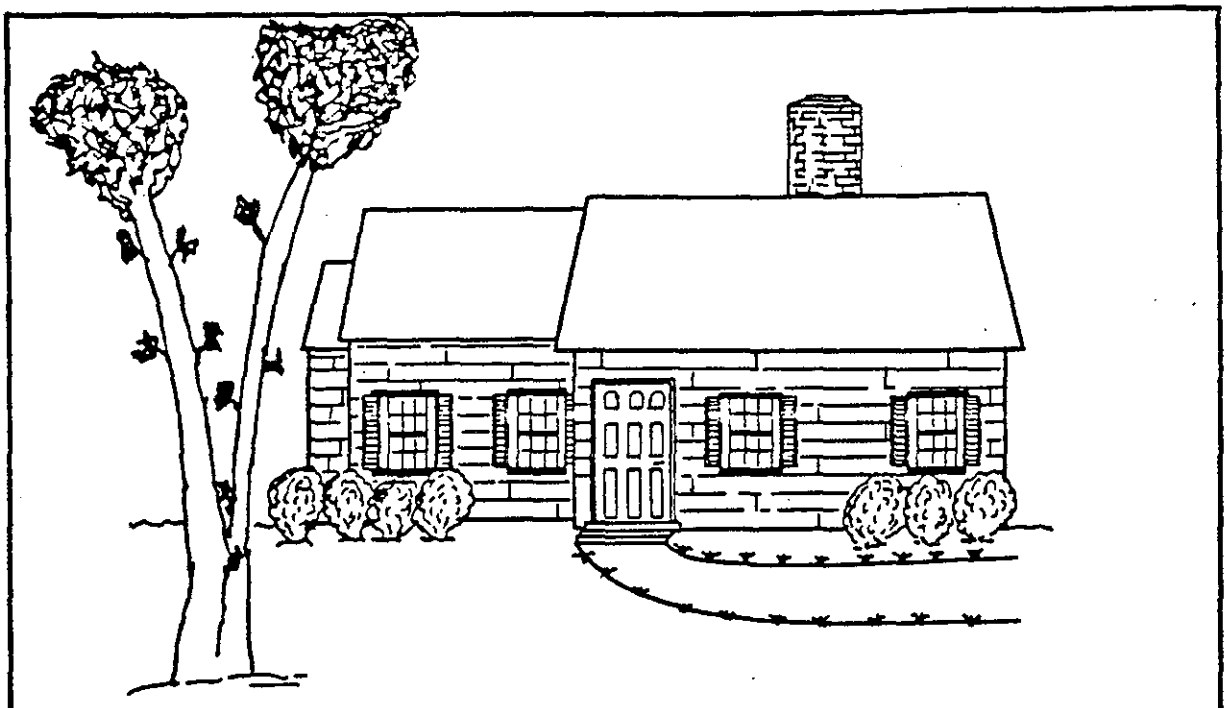
- Landscaping and terracing may be necessary if the height raised is extensive.

Economic Feasibility

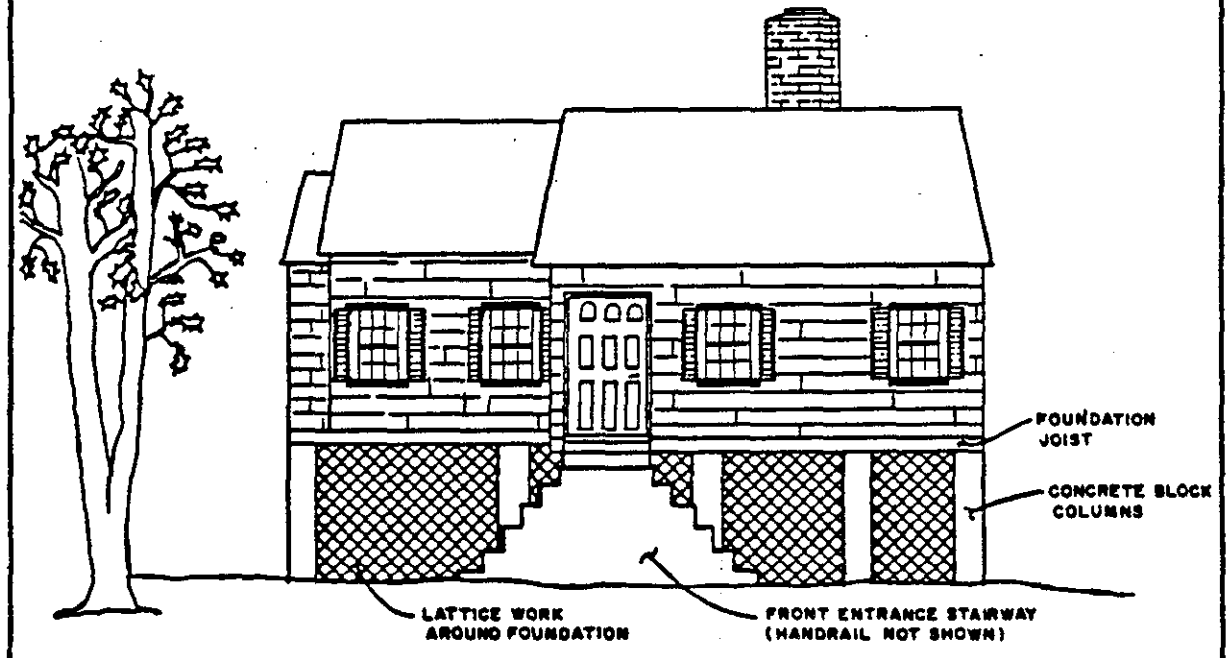
Raising a structure reduces damages that would have been caused by flood events had the structure not been elevated. Cost estimates for raising the superstructure and constructing a new foundation.

	Estimated Total Cost
Raising Structure in-Place	$11,000

Estimated for a 1,600 square foot, $30,000 structure without basement, on raised foundation. Height raised assumed to be 3 feet. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.



RESIDENCE BEFORE RAISING



RESIDENCE AFTER RAISING

Raising Existing Structure

FIGURE 9

METHOD 5

RELOCATING EXISTING STRUCTURES AND/OR CONTENTS

There are basically two options for removing property to a location outside the flood hazard area (Table 5). One is to remove both structure and contents to a flood free site, and the second is to remove only the contents to a different structure located outside the flood hazard area and demolish or reuse the structure at the existing site within the flood plain. Each of these options is shown in Figure 10.

In each case the purpose is to remove damageable property from the hazard area, yet take advantage of opportunities for using the existing property in ways that are compatible with the hazard.

Residential Applications

Both relocation of contents to a new structure and relocation of the entire structure to a new site are costly measures. Only homeowners with high flood damages should consider these measures.

Commercial and Industrial Applications

The relocation of the structure to a new site may not be physically feasible. Relocation of contents is most applicable at complexes where there may be alternative sites available for the relocation of high value merchandise or machinery.

Physical Feasibility

While the experience and equipment exist for moving many different types of structures, there is a practical limit on the size and type of structure that is economically feasible to move to reduce flood losses. Even the most readily relocatable structures are costly to remove.

One or two-story residential and light commercial structures of wood frame on raised foundations or basements are usually easy to move because of the structure weight and access to the first floor joists. Structures of brick, concrete or masonry can also be moved, however additional precautions must be taken to prevent excessive cracking.

Advantages

- Flood damage to the existing contents is eliminated. If the structure is demolished, structural damage is also eliminated.

Disadvantages

- Damage to the structure and site remain if the structure is to be reused.
- Costs to remove contents and demolish the structure are high relative to other measures.

TABLE 5

RELOCATION OF EXISTING STRUCTURE AND/OR CONTENTS

ACTIONS

Relocating the Structure

1. Unhook, modify and rehook utilities.
2. Construct a new foundation.
3. Raise and move structure to new foundation and anchor the building frame to the foundation.

Relocating Contents

1. Construct or purchase a structure outside of flood hazard area.
2. Move damageable contents to new structure.
3. Demolish old structure or preserve it for a new use, compatible with the flood hazard.

CAUTIONS

1. If structure is to remain in flood hazard area, the building and remaining contents will still be susceptible to flooding.
2. If structure is to be relocated, building permits may be required. Plan to spend a couple of months securing an architect or contractor and obtaining permits.
3. If the structure is to remain in the flood hazard ara, occupants should evacuate when a flood is forecast.

Economic Feasibility

With a structure and contents located at a flood hazard site, flood damage occurs. When both structure and contents are removed to a flood free site, this damage is eliminated. The damage reduced by removal is the amount of damage that would have occurred had the structure not been removed. Estimated costs are shown below.

	Estimated Total Cost
Relocate structure	$24,200

Estimated for a $30,000 1,600 square foot structure. Land value of a new site assumed to be $5,000. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.

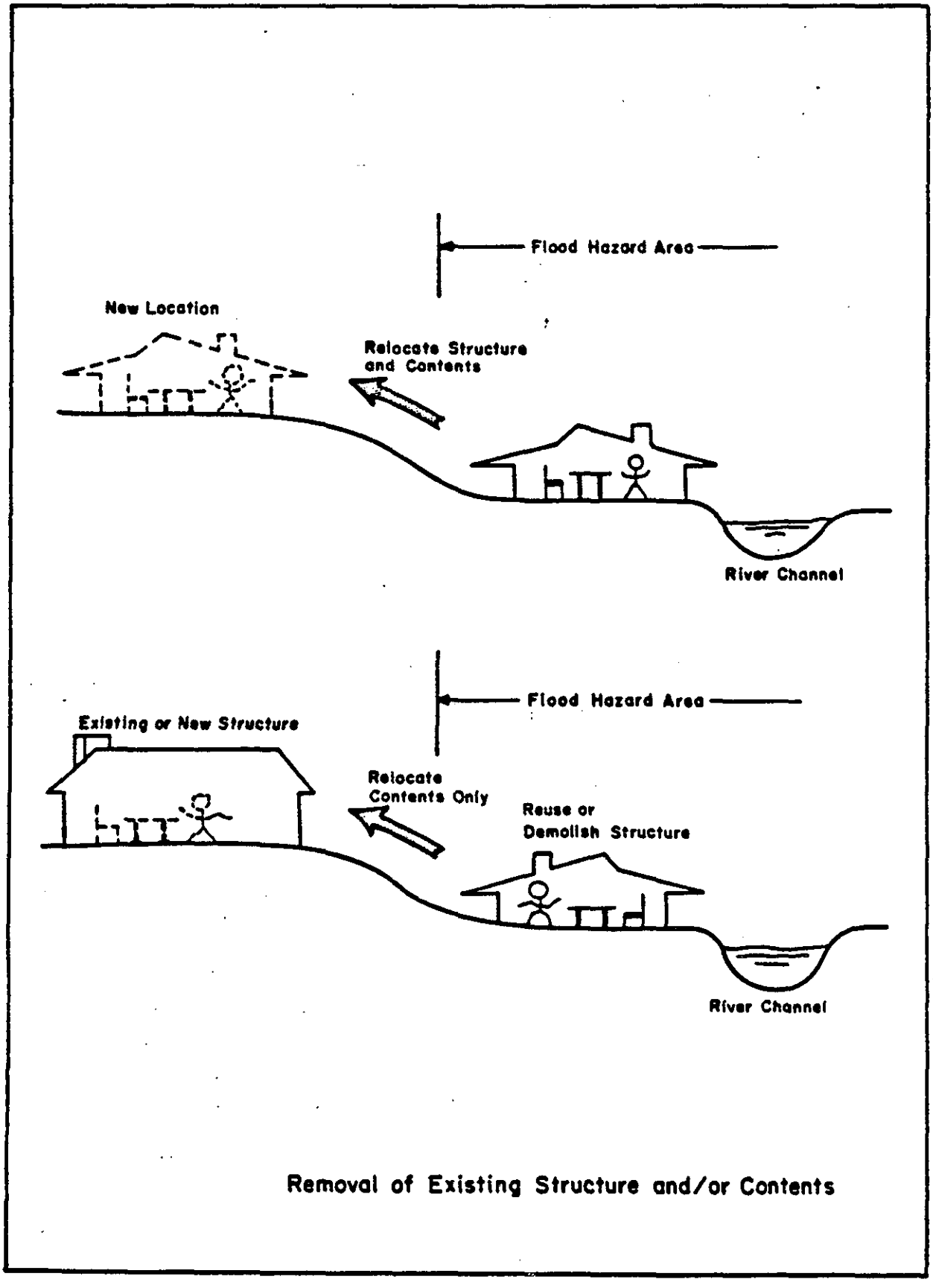
Relocate contents and demolish existing structure	$46,000

Costs were estimated assuming a 1,600 square foot structure in a flood-free location was valued at $30,000 and land at $5,000.

The value of the structure in the flood hazard area was assumed to be $5,000 below market value of structures at flood-free sites and land value was assumed $500.

Costs include 25 percent for contractor's bonds, overhead, profit and engineering.

Replacement cost is sometimes interpreted as being the additional cost to provide a comparable structure at a flood-free site. Under this interpretation this cost could be over $9,500 since an additional $5,000 would be needed for a comparable structure and $4,500 for flood-free land.



Removal of Existing Structure and/or Contents

FIGURE 10

VIII CONSTRUCTION IMPROVEMENTS TO EXISTING STRUCTURES

When making major improvements or repairing existing structures, water resistant materials and damage-reducing construction practices are available to reduce potential damage. Generally, this includes modifying one or more of the following: basement and/or first floor walls, floors, ceilings, exterior walls, insulation, outside utilities, and electrical heating and air conditioning systems. Specific modifications are shown in Figure 11. The numbers attached to each item listed below correspond to the numbers appearing in Figure 11.

1. Overhead energy and communications line.
2. Large space for temporary storage of contents during flood hazard.
3. Separate branch circuit above floodwater level.
4. Elevated main electrical box.
5. Elevated electrical outlets.
6. Air duct outlet for water drainage.
7. Water damage resistant cabinetry.
8. Anchored tank.
9. Elevated outside vent discharge.
10. Impermeable or damage resistant thermal and acoustical insulation.
11. Temporary outside sink drain with positive valve.
12. Water resistant wall material: polyester epoxy paint, plastic tiles, treated wood beams, etc.
13. Positive drain valve for receding water.
14. Manual control valve.
15. Sewer gate valve.
16. Sump pump for cleanup.
17. Extra wide stairway for rapid contents removal.
18. Water damage resistant carpeting.
19. Water damage resistant floor finish: linoleum, rubber, vinyl.

20, 21, 22. Weakened basement window, wall, and floor, respectively, to allow entrance of water to equalize the hydrostatic pressure that could cause structural damage.

23. Anchorage of foundation to prevent flotation and/or overturning.

Advantages

- All residential, commercial and industrial property owners can do this to one degree or another.
- It can be done on a selective basis to modify the property that is susceptible to damage.
- Damage will be reduced because of the actions taken.
- Many actions require little or no additional cost.

Disadvantages

- Flooding will still occur causing residual damage and necessitating cleanup and restoration.
- Damage will be reduced only where more appropriate construction materials and practices are used.

Physical Feasibility

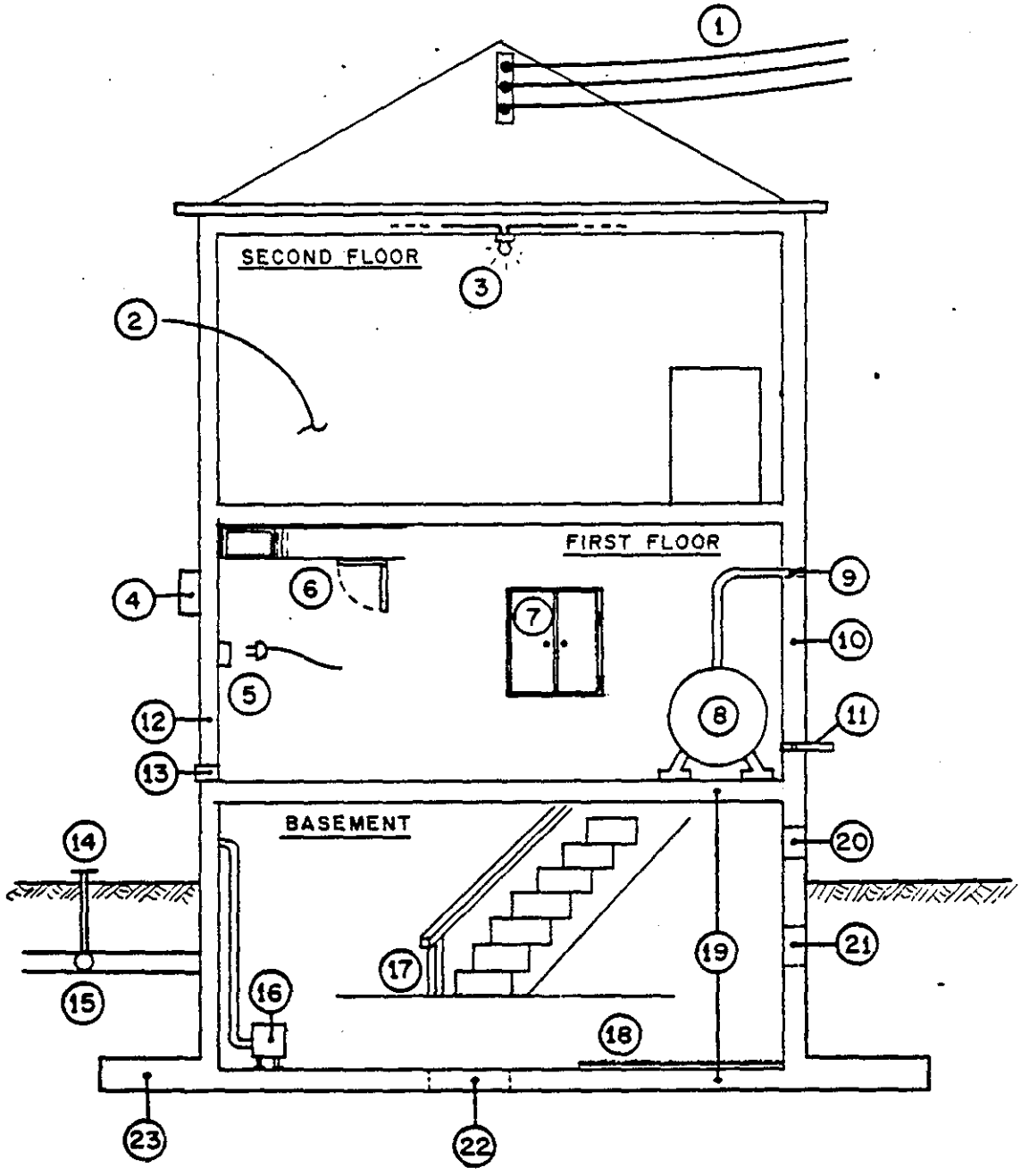
The actions described are generally applicable to all structures to one degree or another and in some combination. Their application is site specific and will depend upon the type of structure and contents, the nature of the flood hazard and the availability of other alternatives. Use of construction materials or practices to reduce potential damage appears to be most appropriate in situations where flooding is not severe or where it is the only feasible alternative—physically or economically. These actions will most likely find their greatest application in combination with other measures.

Economic Feasibility

Computation of damage reduction should be based upon estimates of damage with and without a particular water resistant material or damage-reducing construction practice. This is difficult to determine since damage is not eliminated, as it would be if some property were removed, but is simply reduced. It is felt that most actions would be economically feasible because of the low additional cost of implementation when making major improvements.

Costs

The costs of implementing such measures vary, but generally are low because they can be done as part of new construction, remodeling or repair. Often, the initial cost of implementing such actions is less than 1 percent of the total structure value.



Construction Materials and Practices to Reduce Potential Damage.

FIGURE 11

IX WHICH ACTIONS ARE FOR YOU

METHOD 1

- In general, everyone can benefit from Method 1.
- Some ideas are easy and inexpensive, but others, such as, construction of utility rooms, utlity cells and interior floodwalls are expensive and require professional assistance.
- The simplest of actions can reduce the repair cost and frustration associated with the nuisance of cleaning up after floods.

METHOD 2

- Method 2 also reduces a great deal of the cleanup effort.
- Interior flood damage is reduced.
- Even if water leaks in or rises above the height of your flood shield, you will have filtered out a lot of the sediment and debris.
- Professional advice regarding the structural stability of the building is required before adopting Method 2.

METHOD 3

- Method 3, if used properly, will significantly reduce the damage to your house.
- If you can find help, do some of the work yourself, or get building materials at a discount; these measures may cost less than you think. Remember that dike construction requires proper soils, a degree of compaction, and so on. Walls have to be constructed carefully and fit tightly. Thus, professional advice is recommended.
- These measures require less emergency action on your part. You won't have to depend as much on receiving a flood warning to implement your plan.

METHOD 4

- Method 4 would reduce all but minor nuisance damage except from the extremely large floods.
- Professional help is needed — engineers, house movers and building contractors.
- This method, in most cases, gives long term savings and is dependable.

METHOD 5

- Flood damage to contents and/or structure is reduced.
- Professional help is required.
- This method is extremely dependable in reducing flood damages.

These floodproofing ideas are wise investments if you can be sure they will save you enough money and effort to pay for themselves. If you think that doing too much or too little can be a waste, you may be right!

You may have found that the amount of money needed to finance the best combination of floodproofing is more than you can pay for all at once. In this case, you might consider a low-cost, long term improvement loan. Some people combine their floodproofing with a general remodeling plan and pay for it in one bill. Specific measures which may be incorporated into a remodeling plan can be found in Section VIII. Whether it is to your advantage to borrow money depends to some extent on how long you intend to remain at your present location. If you intend to stay despite the flooding, an investment can begin to pay you back with less flood damage in a short time.

If you cannot afford to invest or feel that you won't get your money back if you do sell, you can still make the most of a limited budget. One way is using the cost-saving measures in this report and, as much as possible, doing the work yourself. Small engineering or architectural firms may be willing to do design work and provide information on construction methods to help you along.

Another way to stretch your budget is to combine methods. For example, you can undertake measures in Method 1 first which reduces you susceptibility to damage and then determine which long range plan would be best.

X LEARN AS MUCH AS YOU CAN BEFORE BEGINNING

Each method has advantages and disadvantages, but some methods may also involve legal restrictions. For example, rewiring electrical outlets must be done according to building codes. In some communities you may be required to obtain a variance from the flood plain zoning ordinance to build a flood wall or dike, and raising a structure usually requires a building permit. You should consult with local officials during the planning stage to determine the legal requirements. The New England Division has numerous publications concerning floodproofing. Additional sources of information are shown on the last page of this report.

XI MAINTAIN THE MEASURES YOU HAVE INSTALLED

One of the unfortunate facts of life is that the things we build will not always last unless we maintain them. You should check your floodproofing measures thoroughly at least once a year and quickly look them over when you suspect flooding may be likely. Ask the following questions.

Have cracks developed?
Are valves stuck?
Have runners become rusty or warped?
Does your pump work?
Have drains become blocked?
Have small animals dug holes in your levees?

In order to protect your investment, you should check all such possibilities and make the needed repairs.

XII SUMMARY

With the exception of moving contents to areas not susceptible to floodings, most floodproofing measures require some professional help and can be costly to implement. Before deciding on a course of action, you should determine the extent of flood hazard at your site and estimate your flood damage potential. When weighing the estimated damages against the costs of various floodproofing measures, remember that the floodproofing cost estimates are based on December 1980 prices. A summary of floodproofing solutions to flood damage for structures now existing in the flood plain is listed below.

1. Modify sewer and utility lines; make adjustments to contents; move damageable items to a higher elevation in the building; and protect specific items with interior walls, cells or rooms.

2. Install seals and shields.

3. Construct a ring levee or wall around the building.

4. Elevate the structure to above the 100-year flood.

5. Move the structure and/or contents out of the flood plain.

6. Observe floodproofing construction practices when making improvements.

7. If you live in a flood plain, purchase and keep current a flood insurance policy. See your insurance agent about how to obtain a policy. If you have a specific question about the National Flood Insurance Program, call the toll free telephone number 800-424-8872, or call the Region I office in Boston, Massachusetts at (617) 223-2616.

XIII GLOSSARY

Buoyancy	The tendency of a body to float or to rise when submerged in water.
Economic Feasibility	A comparison of damage reduced by a floodproofing measures with the estimated cost of implementing the measures. The measure is termed economically feasible if the damage reduced equals or exceeds the cost.
Flood plain	The relatively flat area or lowlands adjoining the channel of a river, stream or watercourse, ocean, lake or other body of standing water that has been or may be covered by floodwater.
Hydraulic	Operated, moved or effected by means of water.
Hydrostatic Pressure	Pressure exerted or transmitted by water.
Impermeable	Not permitting passage of water.
Inundate	To cover with a flood.
Levee	An embankment of earth for preventing flooding.
Permeable	Permitting passage of water.
Sump	A pit at the lowest point of a drainage area serving as a drain.

XIV FOR MORE INFORMATION

SPECIFIC INFORMATION ON REDUCING FLOOD DAMAGES:

1. Consumer Reports, "Basement Water Proofing: Facing the Facts," July, 1974.

2. Federal Disaster Assistance Administration, "When You Return to a Storm Damaged Home," September, 1975.

3. Federal Insurance Administration, "Elevated Residential Structures, Reducing Flood Damage Through Building Design: A Guide Manual," September, 1976.

4. Federal Insurance Administration, "Economic Feasibility of Floodproofing - Analysis of a Small Commercial Building," Federal Insurance and Hazard Mitigation, June 1979.

5. Federal Insurance Administration, "Flood Emergency and Residental Repair Handbook," Federal Insurance and Hazard Mitigation, October 1979.

6. Sheaffer, John R., "Introduction to Flood-Proofing, An Outline of Principles and Methods," University of Chicago, 1967.

7. The Hartford, "Flood-Proofing, A Technique of Avoiding Flood Damage," Hartford, Conn., n.d.

8. U.S. Army Corps of Engineers, "Flood-Proofing Regulations," Washington, D.C., 1973.

9. U.S. Army Corps of Engineers, "Physical and Economic Feasibility of Nonstructural Floodplain Management Measures," Institute for Water Resources, Fort Belvoir, Virginia, March 1978.

10. U.S. Army Corps of Engineers, "Cost Report on Nonstructural Flood Damage Reduction Measures for Residential Buildings within the Baltimore District," Institute for Water Resources, Fort Belvoir, Virginia, July 1977

11. U.S. Army Corps of Engineers, "An Example of Raising a Private Residence to Avoid the Flood Hazard," South Atlantic Division, Atlanta, Georgia, 1976.

12. U.S. Department of Agriculture, "Removing Stains from Fabrics," Home and Garden Bulletin No. 62, 1976.

13. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, "Floods, Flash Floods, and Warnings," Washington, D.C., 1973.

14. SEDA - Council of Governments, "Industrial Flood Preparedness - Proceedings of Flood Warning and Floodproofing Seminar for Industry," April 1979

GENERAL FLOOD INFORMATION:

1. Flood Depth and Frequency Information
   - Army Corps of Engineers
   - Federal Emergency Management Agency
   - U.S. Geological Survey
   - Soil Conservation Service

2. Flood Insurance
   - Your insurance agent
   - Federal Emergency Management Agency

3. Engineering and Architectural Services - Check yellow pages under Consulting Engineers and/or Architects

4. Building Permits - Local officials